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Featuring

Application of Laboratory Research to the Study of Hydraulic Problems

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JOURNAL OF THE

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APPLICATION OF LABORATORY RESEARCH TO THE STUDY OF HYDRAULIC PROBLEMS

By Dr. George H. de Thierry*

Dr. de Thierry visited the United States in 1927, by invitation of the Massachusetts Institute of Technology, to deliver a series of lectures on the hydraulic laboratories of Europe. This paper, which was presented before the Boston Society of Civil Engineers on April 28, 1927, furnishes an excellent résumé of the more important features of his lectures at Technology. — Editor.

We must confess that our knowledge of the phenomena relating to the flow of water is very limited, and what Galileo is reported to have said centuries ago — "I have met with fewer difficulties in discoveries relating to the movements of heavenly bodies, notwithstanding their astonishing distances away, than in investigating the motion of flowing water though taking place before our very eyes" — remains perfectly true in our days. Spectral analysis has revealed to us so many secrets regarding the motion and the structure of celestial bodies whose distance from us is measured by years and years, counted not by days from sunrise to sunrise but by the velocity with which light speeds through space.

In applying hydraulic formulæ we still must confess that when we evaluate the discharge of an open canal or river, for instance, we may possibly commit errors amounting to as much as 20 per cent. We seldom realize that these errors mean in some cases an extravagant outlay of economic means in order to be sure to obtain the desired effect in our structures. In other cases imperfection as far as efficiency is concerned is due to our inadequate knowledge of the true laws of nature.

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* Professor of Hydraulics, Harbor and Canal Engineering, Technical University of Charlottenburg, Germany.

If we look critically on the development of the hydraulic science we are bound to recognize that the most useful discoveries were made by those who applied the laboratory method, while those who looked upon hydraulics as a playground for their mathematical investigations have been in so far unsuccessful as they developed beautiful mathematical formulæ whose only deficiency is that we cannot apply them without fearing to make serious mistakes.

It seems astonishing that on the subject of hydraulics experimental work should have been dormant for so long a period since Leonardo da Vinci's time, for he had uttered the wise warning: "When you try to explain the behavior of water, remember to demonstrate the experiment first and the cause next."

How often has it not happened that on critical examination of some successful engineering construction that has "stood the test of time" the achievement boils down to the mere fact that the structure has not failed, while the pertinent question as to whether the desired result could not have been accomplished just as well and at much less cost in some other way most often has not been considered? Well planned and properly executed laboratory investigation reveals all errors, and in most cases points the way to the better solution of a problem as regards engineering as well as economical aspects, — two considerations that are by no means synonymous in all cases. I believe that in general, engineers in this country are not so much hampered as they are in Europe by traditional considerations. How often does it not happen, especially in Europe, that we dare not cut loose from so-called old and tried-out types of construction? In most cases the "advantages" of such construction types appear to count less in the structure being "tried and true" than in being old and of a familiar pattern. And how often does not the saying of completed works "it has proved itself" mean, aside from the fact that the construction has not collapsed, that no gross obvious mistakes have been noted?

The way to proposed better construction remains in many cases barred because doubts as to suitability and economic value of such betterments arise in the minds of responsible and authoritative officials. Only in very rare cases is it possible to remove such doubts through theoretical approach. The expense and harmful after-effects growing out of failures of new methods are very nearly always so serious that the utmost carefulness is justified, but we seldom realize that by applying the methods of laboratory research to hydraulic structures we are able to form a reliable judgment about the effects of our structures in all their details at an expense which is quite insignificant compared to the costs of failures.

Hydraulic laboratories are therefore no luxury suited only to the needs of such people and countries as can afford to spend money on things of higher and ideal values. The fact that in nearly all construction projects which were submitted to examination in hydraulic laboratories savings could be made amounting to many times the cost of building and operating all laboratories should be sufficient proof that there is no longer any justification for any unfavorable attitude toward modern scientific methods of laboratory investigation.

The methods of laboratory research are based on the application of the laws of similitude established by Sir Isaac Newton long before their application to hydraulics was thought of. These methods have been developed, in the first place, by Dr. Engels of Dresden Technical University during the last thirty years. The first hydraulic laboratory in which engineering problems were tested and submitted to scientific research was Dr. Engels' laboratory of the Technical University of Dresden. Work was started there in 1898, and the fact that at present in Germany hardly a construction is put in execution before having been tested in a hydraulic laboratory shows the necessity of these institutions, since it has been generally recognized how important are the financial results. By showing a series of illustrations of different engineering problems I hope to give an idea of the variety of the applications of hydraulic laboratory research methods. These views were kindly put at my disposal by all superintendents of our hydraulic laboratories in Germany, Austria, Sweden, Russia, and Czechoslovakia, so that I consider myself as a missionary for all these institutions, and wish you to bear in mind that I am speaking for all these men, and it is their work which I am bringing to you.

Fig. 1 shows results of the original investigations of *Engels*, in his first laboratory at Dresden, of the effect of floods on bridge piers. The practical conclusion derived from these experiments was that as the scouring effect of the flood currents occurred principally on the upstream end of the piers, the protection of the foundation by means of sheet piles did not need to be extended to the same degree on the downstream portion of the pier.

Fig. 2 shows the effect of a waste weir in a dike or in the side wall of a canal. It could not be expected by any theoretical consideration that the discharge over the waste weir would affect the level of the canal to the extent shown on this photograph.

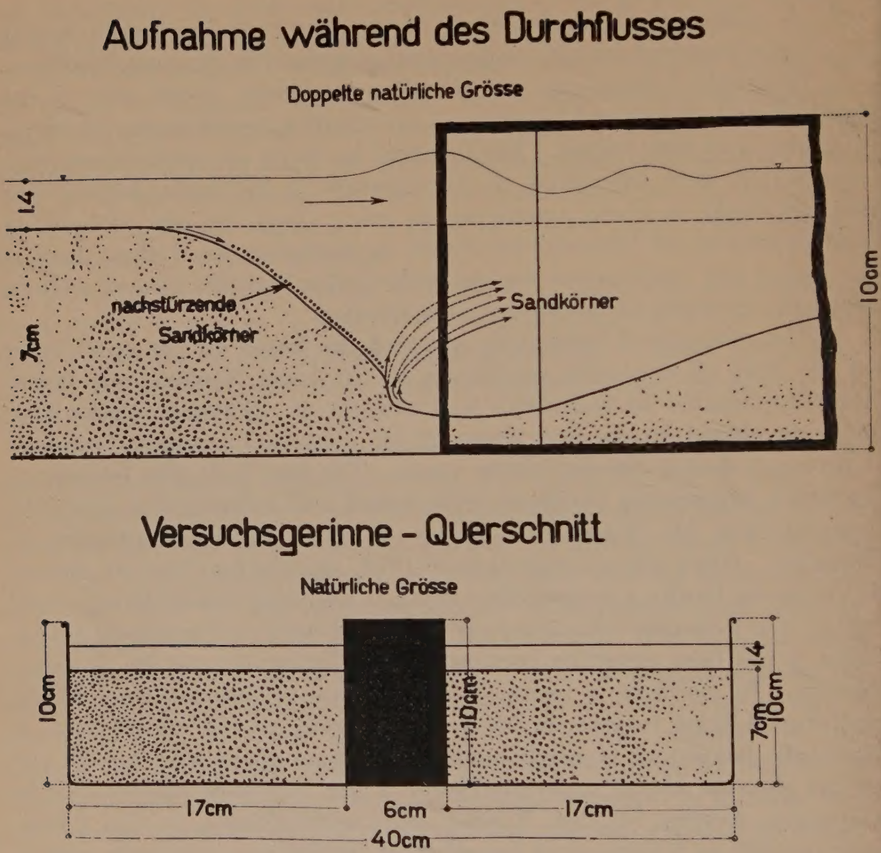


Fig. 1. — Effect of Flood on Bridge Pier (*Engels*)

Upper view — longitudinal section showing effect of scouring

Lower view — cross section through pier before flow of water (lower figure is half the scale of upper figure)

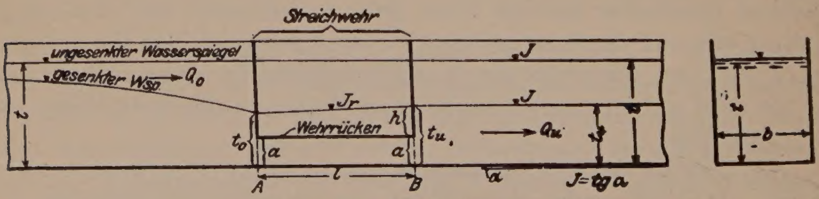


Abb. 29. Verlauf der Spiegellinie.

Längsschnitte: Längen 1 : 200, Höhen 1 : 20, Querschnitte 1 : 20 (unverzerrt).

Fig. 2. — Effect on Water Level of Waste Weir in Side Wall of Canal (*Engels*)

Vertical scale is ten times the horizontal scale

ENTRANCE OF BALTIC NORTH SEA CANAL ON RIVER ELBE

Fig. 3 shows the River Elbe at the entrance of the Baltic North Sea Canal. Owing to the concavity of the river, the depths are absolutely satisfactory for all vessels but serious silting at the entrance makes constant dredging necessary. In order to decrease the amount of dredging it has been proposed to bring the upstream jetty further out, on the assumption that this would modify the currents and would substantially diminish the silt carried and deposited by them. Before appropriations were made for this work it was thought wise to submit the project to laboratory research. At that time *Engels* had no apparatus in his laboratory for producing tidal effects, so he simplified the problem by putting side by side in his flume the model of the canal entrance and its reflected image (*i.e.*, opposite hand model), thereby producing by a flow of constant direction the effects of ebb and flood currents.

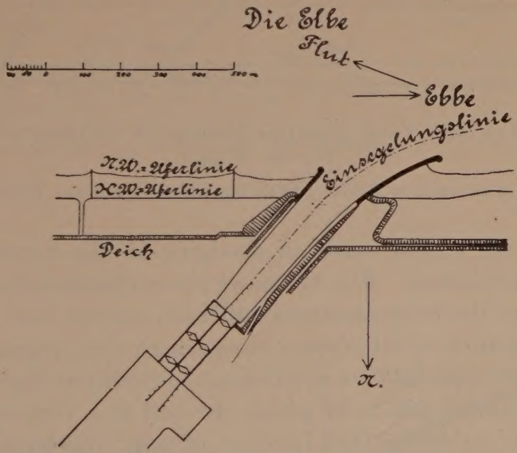


FIG. 3.— ENTRANCE OF BALTIC NORTH SEA CANAL ON RIVER ELBE

N. W. — low-water line H. W. — high-water line

Figs. 4, 5 and 6 show these models and the currents at ebb and flood tides.

The currents in the entrance between the jetties were found to coincide perfectly in model and in nature. The silt deposits produced by introducing peat powder in the current of the model (shown in *Figs. 7 and 8*) proved to correspond in model and in nature to the actual shape of the entrance and its jetties. The next question to be answered by the model investigation was in regard to the effect of the proposed lengthening of the upstream jetty. The results indicated that by lengthening the jetty the silt deposits in the entrance would not be appreciably diminished, so it could be definitely asserted that the increase in efficiency would not be sufficient to justify the cost of the lengthened jetty.

Figs. 9 and 10 show the effect of arcuated low training walls on the ground currents and the sand and silt transported by them. The results of *Engels'* research led to the acceptance of his proposal to build these low training walls. The expensive lengthening of the jetty was obviated thereby, and the annual costs of dredging in the entrance have been appreciably diminished. *Fig. 11* shows the entrance according to soundings made after the improvements had been carried out.

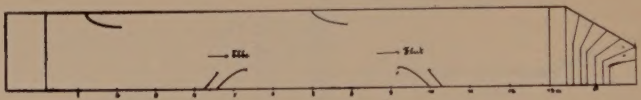


FIG. 4. — PLAN SHOWING MODELS OF ENTRANCE IN FLUME (*Engels*)

Entrance of Baltic North Sea Canal on River Elbe

The application of laboratory research to river engineering is one of the most difficult and delicate problems on account of the different factors under the combined effects of which the bed of a river is shaped. The configuration of a river bed is a function of water discharge and the transportation of solid matter. The water discharge varies constantly, the phenomena of one year seldom resembling those of a preceding or following year. The size and quantity of the sediments carried by a river differ according to varying events in the hydrological basin of the river. The formation of sand banks and the transformation and shifting they undergo are therefore the effect of manifold factors. Besides the linear reduction of the model as compared with nature, we must consider also the varying heights of gauge and their duration. As regards the reduction scale of our models we, so to speak, put them under a magnifying glass by exaggerating the depth scale. We cannot bring the quantity and size of grain of the sediment into accord with either the scale for lengths, for widths or for depths. In order to obtain a model river bed resembling nature, therefore, we must adopt in our model currents strong enough to move the sediment and yet not too heavy to obtain the formation of shoals similar to nature. Usually the scale for the height of gauge is the same as that for the depth, but we must, according to the time scale we adopt, render in our model the variation of water level and the respective

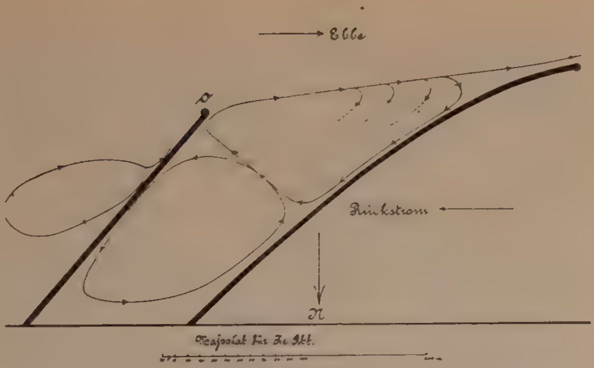


Fig. 5. — Ebb current

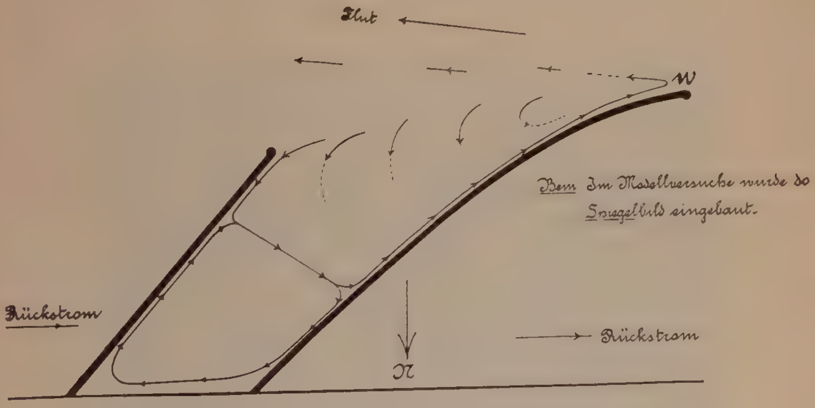


Fig. 6. — Flood current

Effect of Ebb and Flood Currents in Model (*Engels*)

Entrance of Baltic North Sea Canal on River Elbe

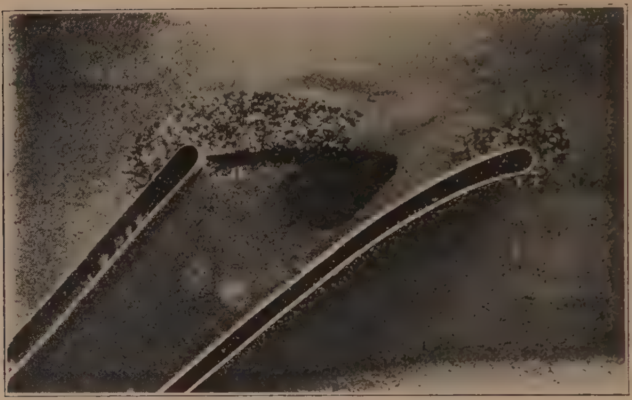


FIG. 7. — Ebb current

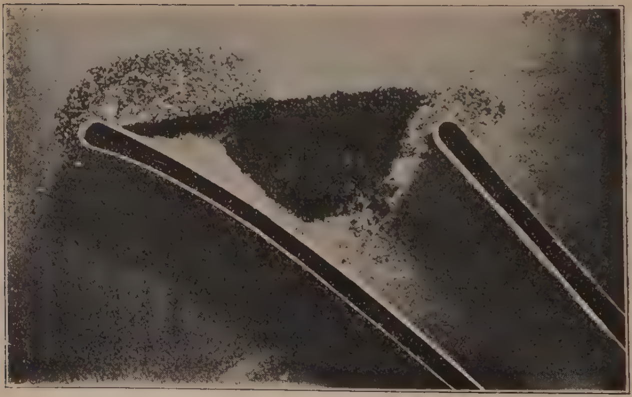


FIG. 8. — Flood current

EFFECT OF PROPOSED LENGTHENING OF UPSTREAM JETTY (*Engels*)
Entrance of Baltic North Sea Canal on River Elbe

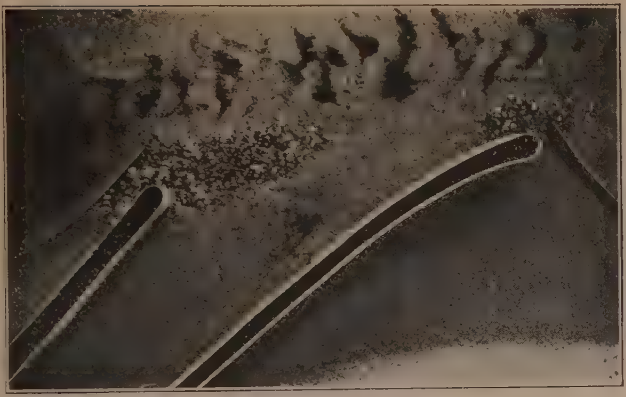


FIG. 9. — Ebb current

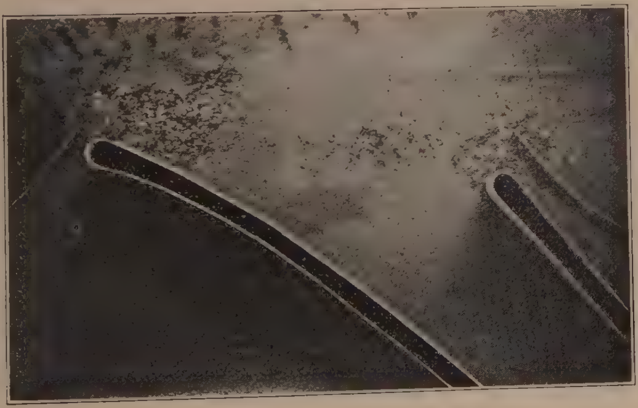


FIG. 10. — Flood current

EFFECT OF LOW TRAINING WALLS (*Engels*)

Entrance of Baltic North Sea Canal on River Elbe

durations as they occur in nature. In assuming that a certain number of hours represents a hydrological year, we usually vary the discharge and height of gauge of our model according to the natural data, by comparing and combining the height and duration of the water levels in, for instance, a period of ten years. Although the solution of these problems seems to be attended by more unknown quantities than equations, it is a curious fact that the first of these investigations were made on river models. *Osborne Reynolds* of Manchester University was the man who first applied laboratory methods to a problem of river engineering. He experimented on a small scale model of the Mersey estuary, the problem being seriously complicated by the effect of the tides. Nevertheless, he obtained in his model a fairly true reproduction of the configuration of the Mersey estuary.

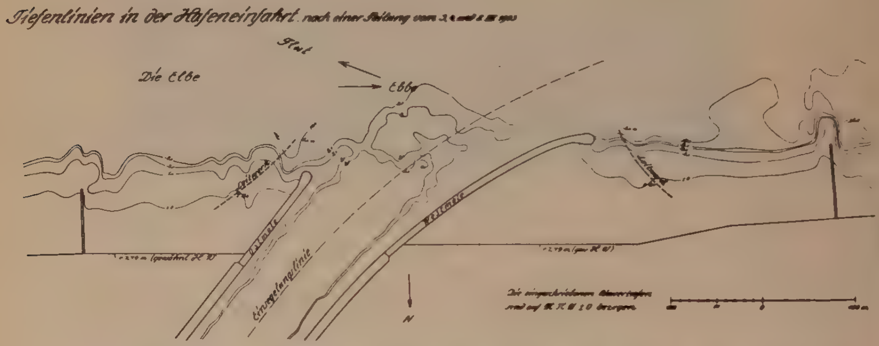


Fig. 11.—Entrance of Baltic North Sea Canal on River Elbe according to Soundings Made after Construction of Low Training Walls

This method has been further developed by *Koch* of the Darmstadt University, by *Engels*, by *Kruger* in his laboratory of Wilhelmshaven, and by *Krey*, all of them experimenting on harbor models. *Krey*, of the Government laboratory of Berlin, operated with an automatically acting tidal apparatus regulating the height of the tides and the currents they produce.

Low Water Regulation of Section of River Elbe

Fig. 12 shows the model investigations of *Krey* for a low-water regulation of a section of the River Elbe below Magdeburg.

At the top to the left appears the natural configuration of the Elbe after a duration of a twenty-year period in nature, equal to two hundred and forty hours in the model with true reproduction of the changes in the discharge. The shallow crossing is clearly shown in this view, but in this connection we must bear in mind that the reduction scale for lengths and widths was 1 : 200; for depths and heights of gauge, 1 : 40; for size of sand grain, 1 : 5; for the slope, 1 : 1; for the discharge per second, 1 : 30,000; for time, 1 : 730 (*i.e.*, 12 hours = 1 year); for quantity of sediment, 1 : 3,000,000.

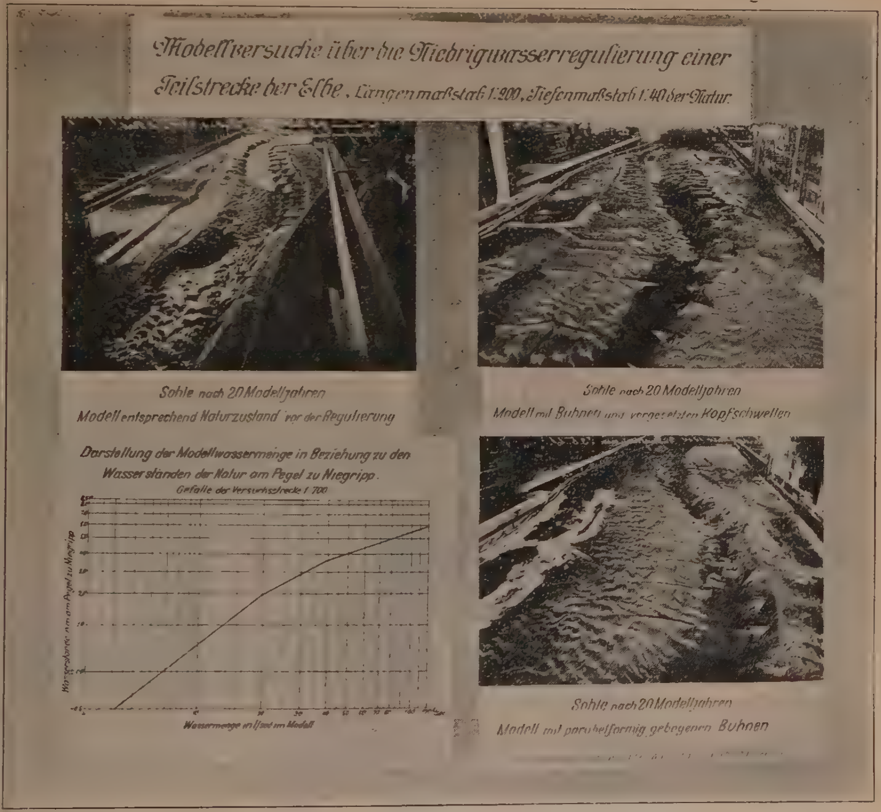

Modellversuche über die Niedrigwasserregulierung einer Teilstrecke der Elbe. Längenmaßstab 1:200, Tiefenmaßstab 1:40 der Natur.
Sohle nach 20 Modelljahren
Modell entsprechend Naturzustand vor der Regulierung
Sohle nach 20 Modelljahren
Modell mit Buhnen und vorgesetzten Kopfschwellen
Darstellung der Modellwassermenge in Beziehung zu den Wasserständen der Natur am Pegel zu Niegripp.
Gefälle der Versuchsstrecke 1:700
Wasserstände in m am Pegel zu Niegripp
Wassermenge in l/sec im Modell
Sohle nach 20 Modelljahren
Modell mit parabelförmig gebogenen Buhnen

FIG. 12. — MODEL OF A STRETCH OF RIVER ELBE (*Krey*)

The lower left-hand portion shows the discharge per second traced out on logarithmic paper as abscissæ as function of the height of gauge (ordinates). This graph shows clearly a marked breaking point of the discharge curve, due to variations of cross section, submerged cross dikes, and inundation of the foreland between dikes and river.

The lower right-hand view shows a good continuity of the deep channel, obtained by forming the head of the cross dikes according to a parabola.

TRANSPORTATION OF SEDIMENT AT BRANCHING OF RIVER

Figs. 13, 14 and 15 show the effect of the branching of a river upon transportation of sediment as obtained by *Rehbock* in his laboratory at Karlsruhe. Only 3 to 10 per cent of the sediment carried by the main river above the division follows the straight course of the river. *Rehbock* attributes this singular fact to an eddy formed on the bank of the side branch, which causes a depression of level in the branch and a cross current from the main river to the side branch. The filaments are attracted by the branch and transport the sediment into it.

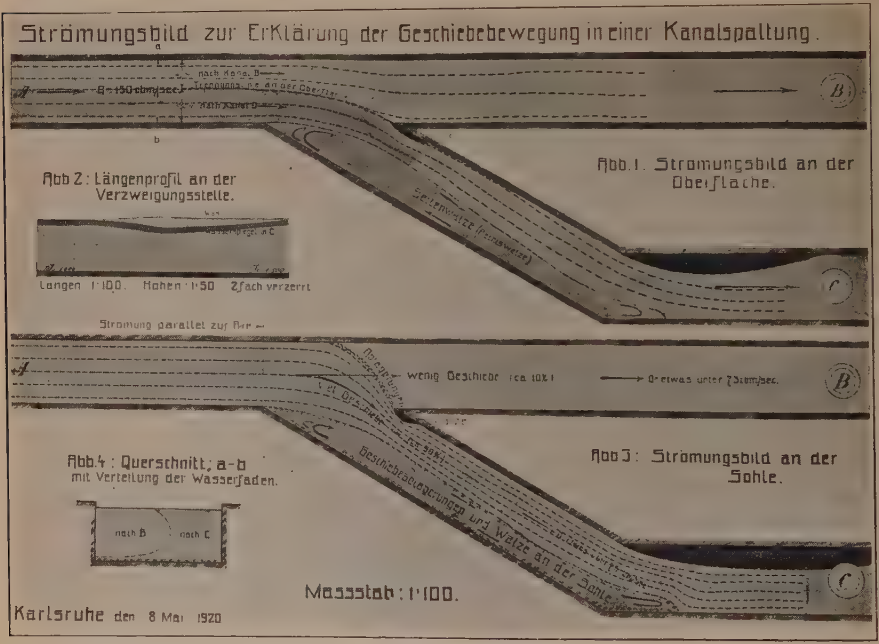

Strömungsbild zur Erklärung der Geschiebebewegung in einer Kanalspaltung.
a
b
nach Kanal B
nach Kanal C
Abb. 1. Strömungsbild an der Oberfläche.
Abb 2: Längenprofil an der Verzweigungsstelle.
Längen 1:100. Höhen 1:50 2fach verzerrt
Strömung parallel zur Achse
wenig Geschiebe (ca 10%)
Q etwas unter 75 cbm/sec.
Abb 3: Strömungsbild an der Sohle.
Abb. 4: Querschnitt: a-b mit Verteilung der Wasserfäden.
nach B
nach C
Geschiebeablagerungen und Walze an der Sohle
Massstab: 1:100.
B
C
Karlsruhe den 8 Mai 1920

FIG. 13. — TRANSPORTATION OF SEDIMENT IN CASE OF A DIVISION OF FLOW (*Rehbock*)

SEEPAGE THROUGH SAND DAM

Figs. 16, 17, 18 and 19 show the seepage through a sand dam according to *Rehbock's* investigations. The course of the water filaments is demonstrated by injecting aniline color at different depths on the upstream side of dam. The water filaments follow the direction of the line bisecting the angle of incidence.

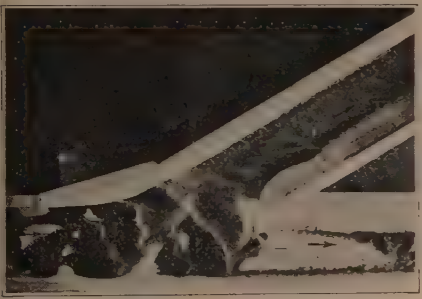


FIG. 14. — Angle of branch = 30°; 2.7 per cent of sediment carried in main stream

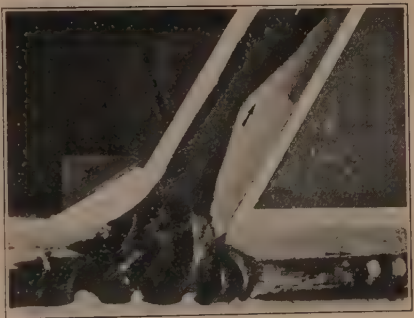


FIG. 15. — Angle of branch = 60°; 3.8 per cent of sediment carried in main stream

TRANSPORTATION OF SEDIMENT AT BRANCHING OF RIVER (*Rehbock*)

The problem of dissipating energy below weirs is studied closely in nearly all hydraulic laboratories. A satisfactory solution of this problem is of great financial significance, since both the length to which the river bed must be protected against the scouring effect of the drop, and also the running expenses for filling up the pools scoured out during flood discharges, can be greatly reduced by adopting adequate means to dissipate the energy of the drop.

DISSIPATION OF ENERGY BELOW WEIRS

Figs. 20 and 21 show the weir proposed by *Rehbock*, as a result of laboratory investigations, which was subsequently built at Zurich by the Swiss Federal Railways in connection with a relocation of the railway tracks on the left side of the lake. The results have been in perfect accordance with what the small scale model showed, as has been proved during a high flood.

Figs. 22, 23, 24 and 25 show the effect of *Rehbock's* dentated sill in dissipating energy below the weirs at Friedland in East Prussia, and at Ryburg-Schwörstadt on the Rhine between Bâle and the Lake of Constance.

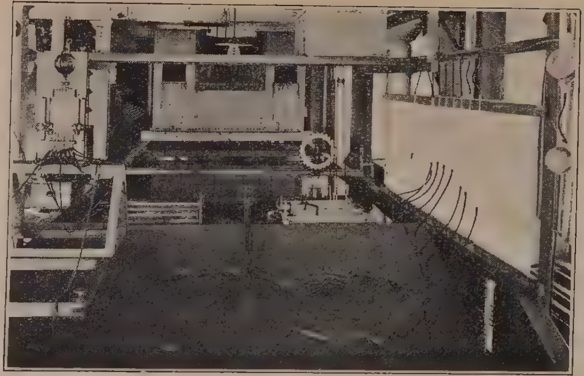


Fig. 16

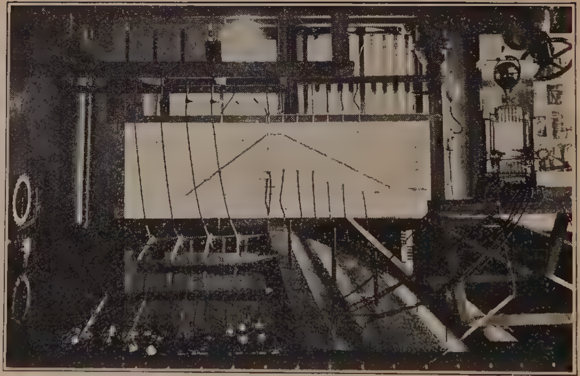


Fig. 17

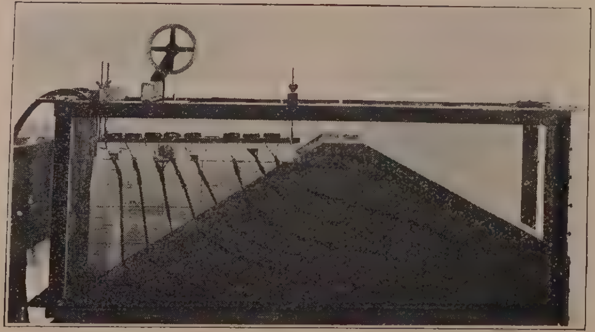


Fig. 18

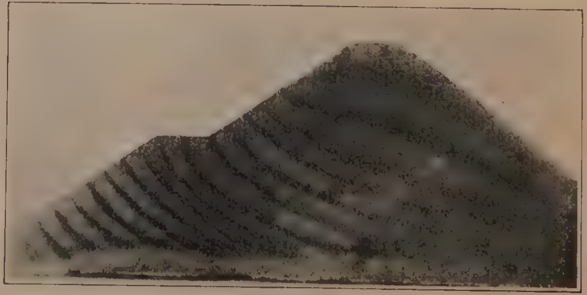


Fig. 19

Seepage through Sand Dam (*Rehbock*)

In Figs. 18 and 19, course of filaments is shown in dam

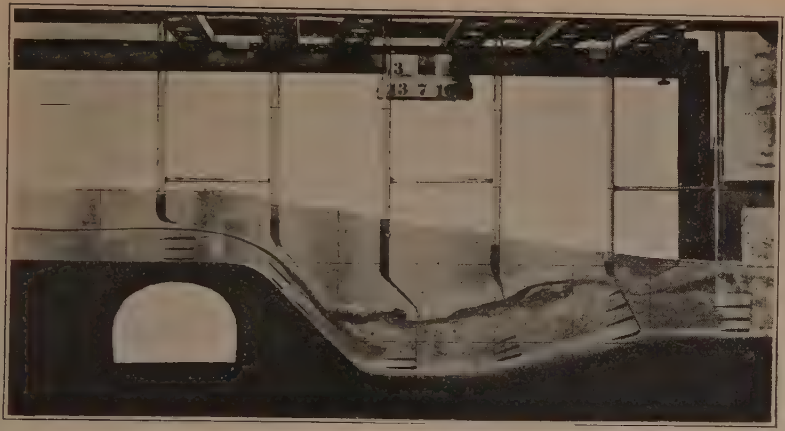


FIG. 20. — Surface eddy — energy line lowered, energy dissipated

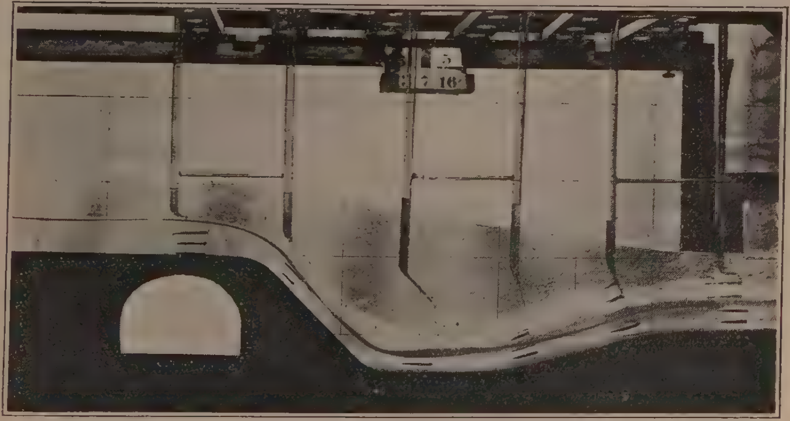


FIG. 21. — No surface eddy — energy line high

DISSIPATING ENERGY BELOW WEIRS (*Rehbock*)

Tunnel under River Sihl (Zurich) — Effect of surface eddy shown by Pitot tubes

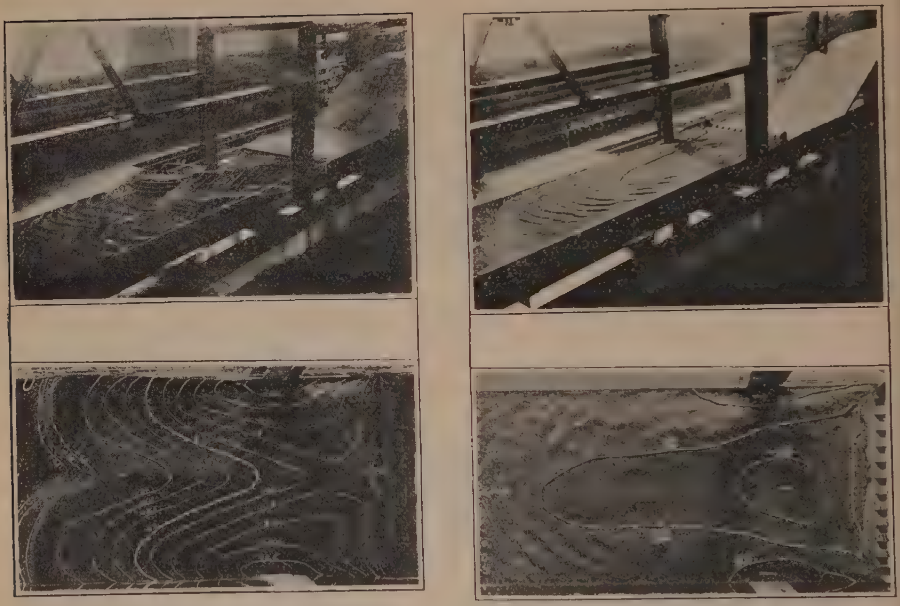


FIG. 22. — Without dentated sill

FIG. 23. — With dentated sill

DISSIPATION OF ENERGY AT FRIEDLAND WEIR BY USE OF DENTATED SILL ON APRON (*Rehbock*)

Contour interval is 0.5 meter in nature (1.25 centimeters in model)

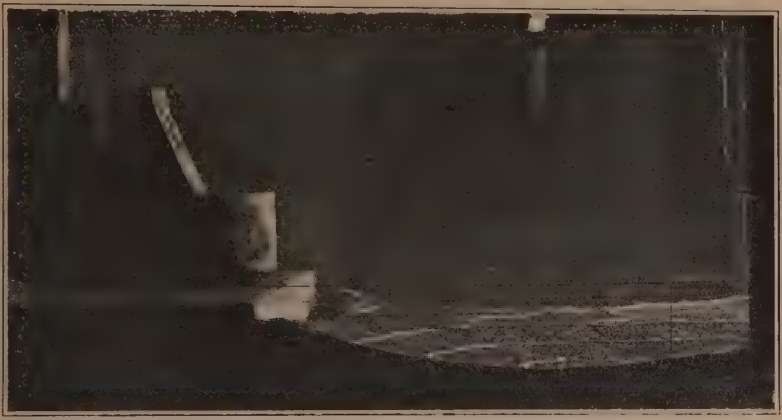


FIG. 24. — Without dentated sill — length of pool is 21.7 meters

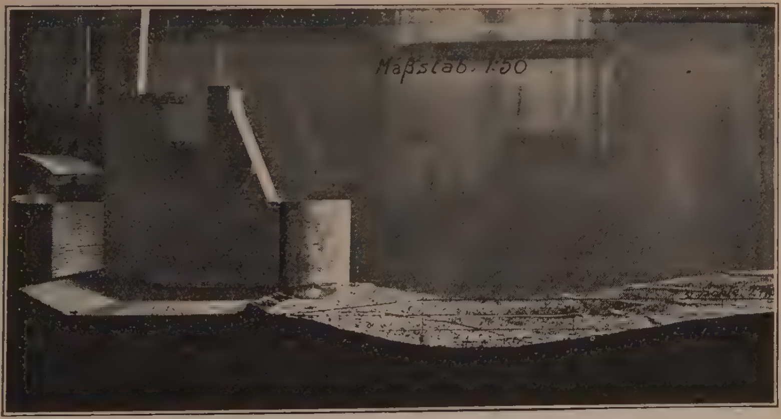


FIG. 25. — With dentated sill — length of pool is 17.5 meters — under same flow of water as in Fig. 24

MODEL OF WEIR AT RYBURG-SCHWÖRSTADT ON THE RHINE (*Rehbock*)

Shannon River Power Development

Dr. Ludin, at Charlottenburg, the writer's colleague who lectures on weirs and water-power constructions, has been requested by a German firm, constructing the power plant on the Shannon River for the Irish government, to investigate the proposed weir.

Figs. 26, 27, 28, 29 and 30 illustrate the results of *Dr. Ludin's* experiments with different shapes of weirs, with special reference to the resultant scouring of the bottom downstream of the weir apron.

Fig. 31 shows a deep scouring of the bottom due to the ground eddy formed under the jump below the weir apron. Very little energy is dissipated by friction on the surface of the apron.

Fig. 32 illustrates clearly the water jump. The surface eddy lies above the apron, and changes in the discharge made no difference. By maintaining the same length of the apron (*Figs. 33 and 34*), and putting a wedged sill at its lower end, the whole energy is dissipated before the jet leaves the apron. There is no scouring of the bottom below the weir. This fact can be explained by the effect of the surface eddy which acts as a brake on the surface current. The eddies at the perpendicular drop of the weir, and the ground eddy between the inclined sill and the ending sill, act as brakes on the under currents. By these combined effects the velocity of the current is diminished to such a degree that no scouring effect can be observed downstream of the weir.

The investigations showed further that by shortening the piers, and thereby subdividing the length of the weir, a better distribution of the jet could be obtained, so that the lateral eddies contribute to dissipate the energy of the flow through the opening in the discharge weir. This effect is especially valuable during the maximum discharge over the weir.

Figs. 35, 36 and 37 show longitudinal sections of the surface of the different scoured pools, represented as a kind of surface profile. The scouring effect of the original project amounting to 13,300 cubic meters could be brought down to 2,300 cubic meters equally apportioned over the middle part of the weir structure.

Undoubtedly the application of hydraulic laboratory methods has brought about the most important advancement in the construction of locks. The problem in this case is similar to that of weir construction, in that the energy of the water filling the lock must be dissipated in order that the hawsers by means of which ship or canal boat is fastened in the lock may not be subjected to excessive tension.

Laboratory methods were at first applied to lock construction about

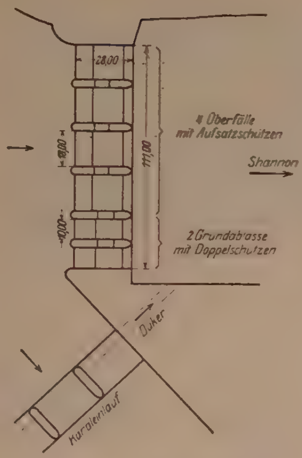


FIG. 26. — Original design

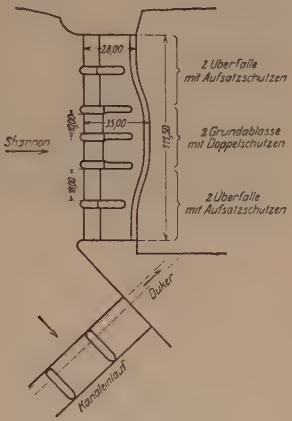


FIG. 27. — Improved final design — result of laboratory research

ORIGINAL AND IMPROVED DESIGN OF WEIRS (*Ludin*)
Shannon River Power Development

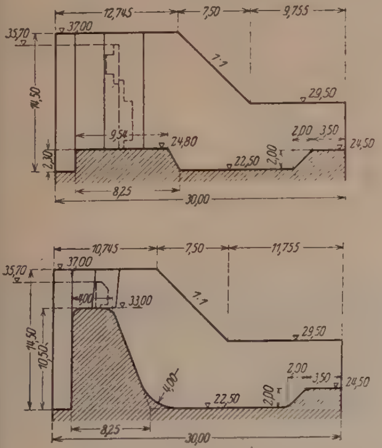


FIG. 28. — Original design

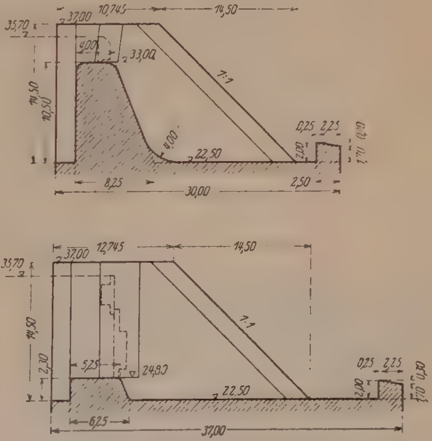


FIG. 29. — Improved final design — result of laboratory research

CROSS SECTIONS THROUGH SPILLWAY AND SLUICE (*Ludin*)
Shannon River Power Development

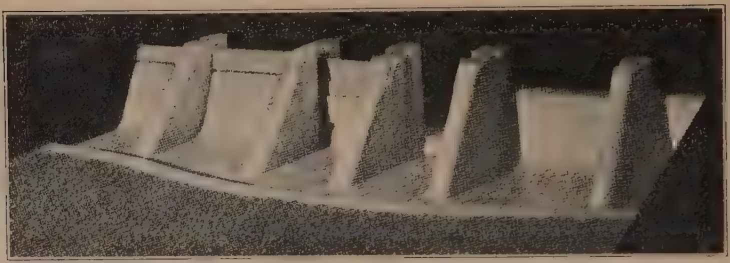
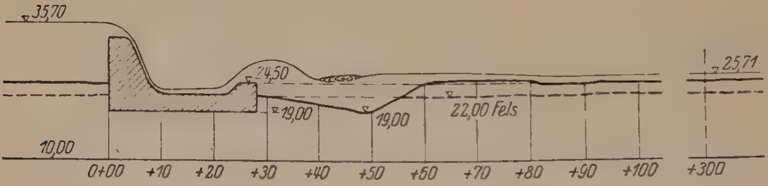


FIG. 30. — MODEL OF IMPROVED FINAL DESIGN OF WEIR (*Ludin*)
Shannon River Power Development



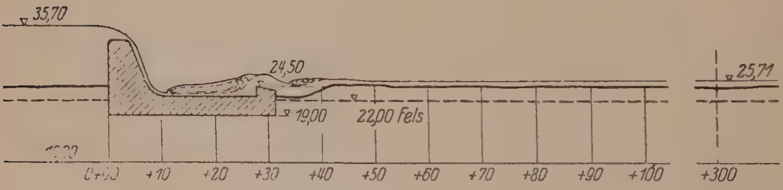


FIG. 31 (upper figure). — Original design
FIG. 32 (lower figure). — Improved final design — result of laboratory research
CROSS SECTIONS OF SPILLWAY AND POOL (*Ludin*)
Shannon River Power Development

FIG. 33. — Original design

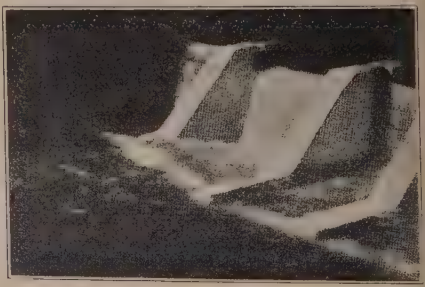


FIG. 34. — Improved design

MODELS OF ORIGINAL AND IMPROVED DESIGN (*Ludin*)
Shannon River Power Development

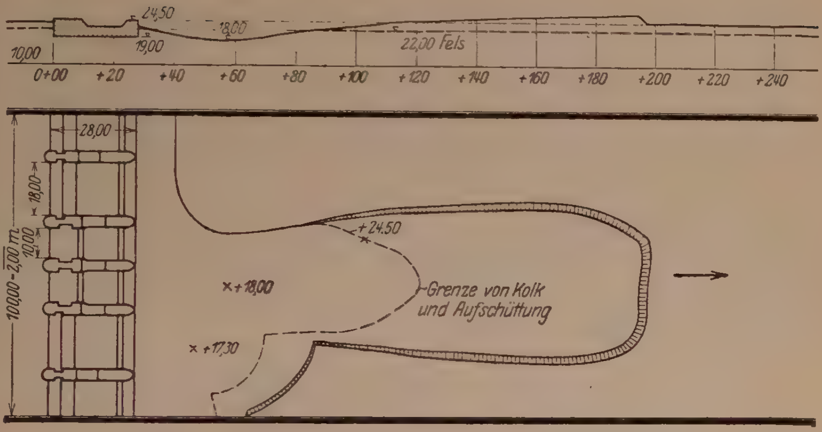


FIG. 35. — Original design

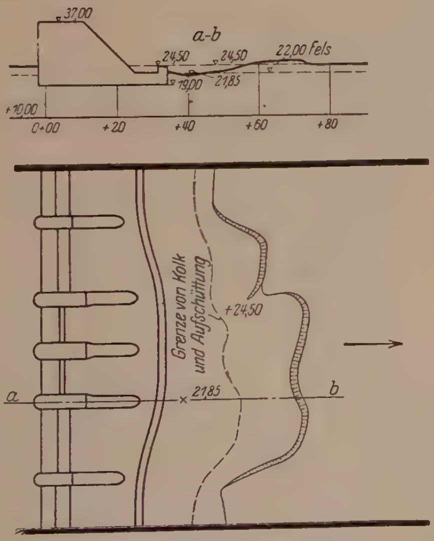


FIG. 36. — Improved design

COMPARISON OF POOL SURFACES BELOW WEIR (*Ludin*)

Shannon River Power Development

Longitudinal sections show deposit downstream from pool twenty years ago when the Prussian government projected the canal between the Rhine at Ruhrort and Herne on the canal between Dortmund and the harbor of Emden on the North Sea. The canal has been built for boats of 1,700 tons' carrying capacity. Throughout its length it crosses the mining district, and as serious subsidence of the earth's surface had been observed for a long time, due to the galleries of the mines, a form of lock construction had to be found which would stand a certain amount of settling. Lifting gates were adopted, but as filling and emptying the locks by means of longitudinal canals was out of the question, short canals in the upper and lower heads of the lock have been introduced with great success both from the technical and from the financial points of view.

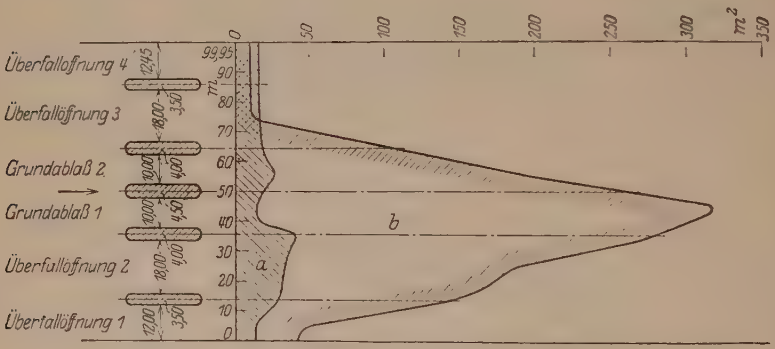


Fig. 37. — Comparison of Pools (*Ludin*)

Shannon River Power Development
Improved design, 2,300 cubic meters
Original design, 13,300 cubic meters

Seven or eight years ago the Dutch government, when planning a new lock for the canal between Amsterdam and the North Sea, wished to have its design submitted to a test in the Berlin Laboratory of *Dr. Krey*. This lock, with its length of 400 meters, its width of 50 meters and depth of 15 meters, will be the largest lock in the world. In order to shorten the time of filling and emptying a lock it is necessary to increase the discharge per second as much as possible. The experiments for the Rhine-Herne, previously made, had shown, however, that it was further necessary, in order to avoid wave action in the lock, to increase the discharge uniformly to the maximum, and after a certain period of maximum discharge diminish it gradually to zero again.

Model Investigations of Canal Locks

Fig. 38 shows the results of *Dr. Krey's* investigations. On the axis of ordinates are marked the forces on the hawsers of a 45,000-ton ship, a model of which was fastened in the model lock (scale 1 : 40). The abscissæ are the time required for filling the lock. The curve [A] on the right-hand side shows that by adopting short canals with pure rectangular sections the filling of the lock required from 11 to 15 minutes, and that with the shortest time of 11 minutes forces of up to nearly 100 tons were exerted on the hawsers. The filling by long side canals with side orifices [A*] requires on an average 10 minutes, but the forces on the hawsers range between 20 and 50 tons. Better results were obtained by giving the section of the canal a triangular shape at its bottom, so that as soon as the vertical closing gate is raised the condition of increasing the discharge from zero to its maximum is fulfilled. Yet according to the curve [B], which shows that in adopting for the canal the cross section shown at the upper end of the curve [B], the time for filling the lock can be reduced to from 7 to 11 minutes. But with a 7-minute filling the tension on the hawsers still goes up to about 92 tons. The best results were obtained with short canals, and a section of the canal as shown on the left-hand side C — narrow rectangle with triangular bottom —

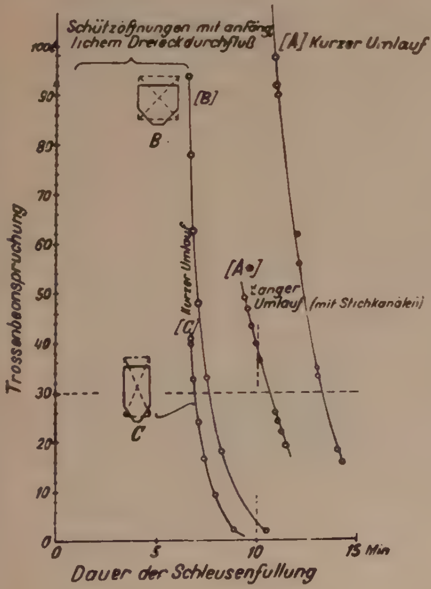


Fig. 38. — Lock on Amsterdam — North Sea Canal (*Krey*)

Hawser tension for varied methods and rates of filling the filling of the lock can be reduced to 6 to 8 minutes, and the tension of the hawsers does not go beyond 41 tons, but is diminished to 10 tons if the time is increased to 8 minutes.

Dr. Krey's proposal based on the results of his investigations has been accepted by the Dutch government, and a saving of $475,000 will be made on the construction.

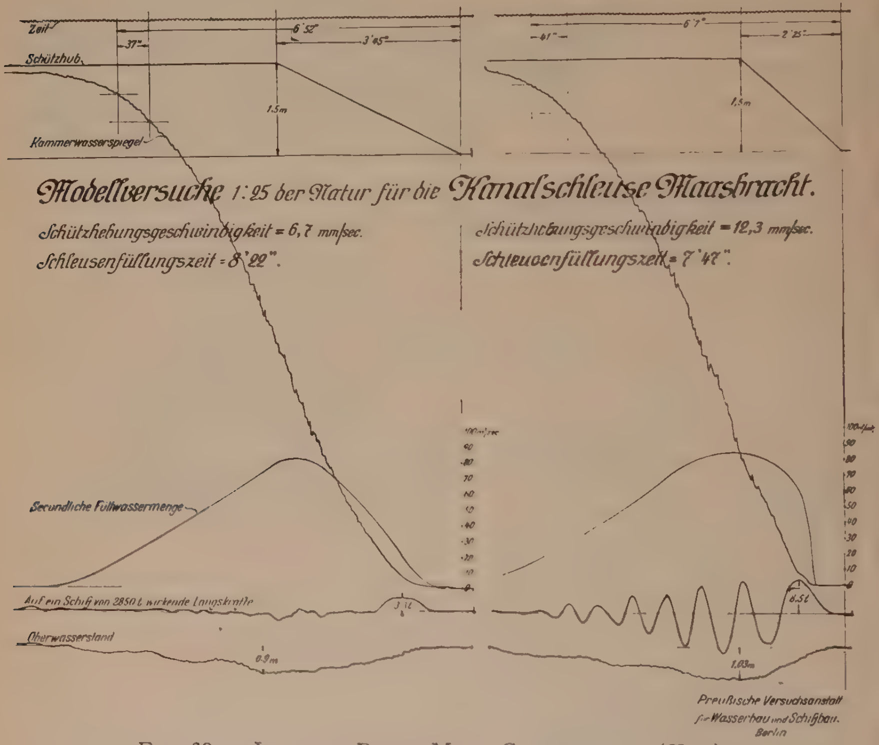


FIG. 39. — LOCK ON RIVER MAAS CANALIZATION (*Krey*)

Fig. 39 is a photograph of the original graph for an investigation of another lock for the canalization of the river Maas for the Dutch government. In this case a canal lock (136 meters × 16 meters × drop of the lock 8.40 meters) was submitted to the test. Two cases are reproduced here: on the right-hand side the cylinder valve with triangular dentated lower end was raised in 2 minutes 25 seconds to its maximum height of 1.5 meters; on the left-hand side the time for raising the valve was 3 minutes 45 seconds. The top line shows the time registration; the second line the raising of the cylindrical valve; the irregular curve marks the water level in the lock chamber raised from the downstream level to the upstream level 8.40 meters. In the case on the right-hand side the discharge per second was raised very quickly to a maximum of about 80 cubic meters per second, while on the left-hand side it is seen that the discharge curve is not nearly as steep as in the other case. The curves under the axis of abscissæ show the forces on the hawsers. In the case of the short time of filling, the maximum tension rises to 8.5 tons, but by increasing the time of filling to 8 minutes 22 seconds the force on the hawsers drops to 3.3 tons.

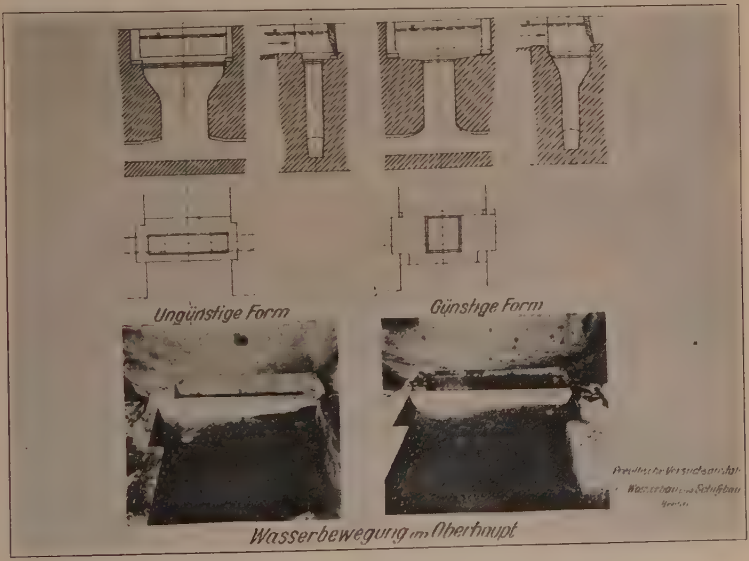


FIG. 40. — ANDERTEN CANAL LOCK (*Krey*)

The curve at the bottom of the graph shows that although the discharge per second was practically the same in both cases, the level of the canal upstream was lowered in one case 1.03 meters; in the other, 0.9 meters. Thus it is proved that not the quantity of water discharged into the lock but the discharge as a function of the time is of greatest importance with regard to the wave action in a lock.

Fig. 40 shows the influence of the shape of the intake in the floor of the upper lock gate. These model experiments were made for the Anderten lock which had a fall of 16 meters. The design at first suggested (shown upper left) was that of a narrow intake reaching over the whole width of the lock gate, the gate recesses being unsymmetrical. This resulted in eddies with strong air suction. Experiments with different sections showed that the device on the right-hand side was preferable, a section nearly square in shape, with gate recesses of equal depth. This model produced no eddies.

Experiments showed that by putting the intake opening further from the gate, the formation of eddies was increased, thereby demonstrating the influence of the gate on inflow. If the incline in the upper figure is made steeper and rounding the eddy conditions are changed.

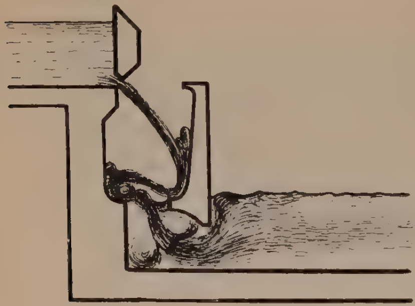


Fig. 41. — At upper gate

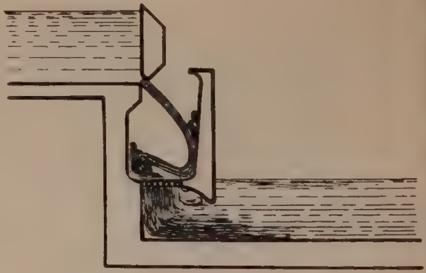


Fig. 42. — At upper gate

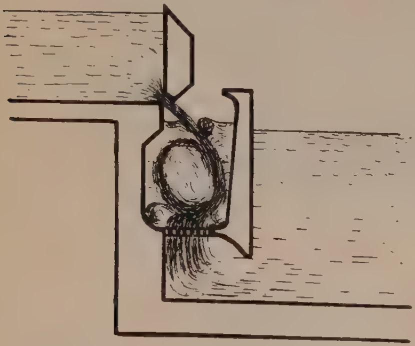


Fig. 43. — At upper gate

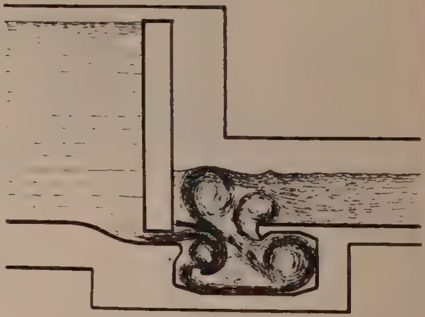


Fig. 44. — At lower gate

Dissipating Energy at Ladenburg Lock on River Neckar Canalization (*Burkhardt*)

Ladenburg Lock on River Neckar Canalization

On the Neckar canal, which is under construction and will be used for water power and for the navigation of 1,300-ton boats between Stuttgart and Mannheim on the Rhine, a lock will be put in service this

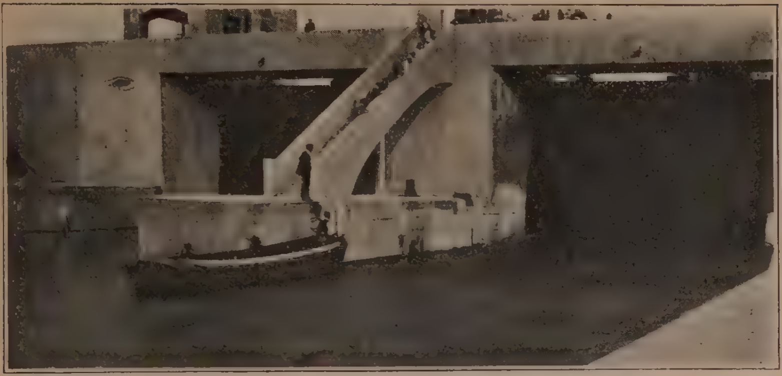


FIG. 45. — LADENBURG LOCK ON RIVER NECKAR CANALIZATION (*Burkhardt*)

Downstream end — lock being emptied. Note improvement over old type (Fig. 46)

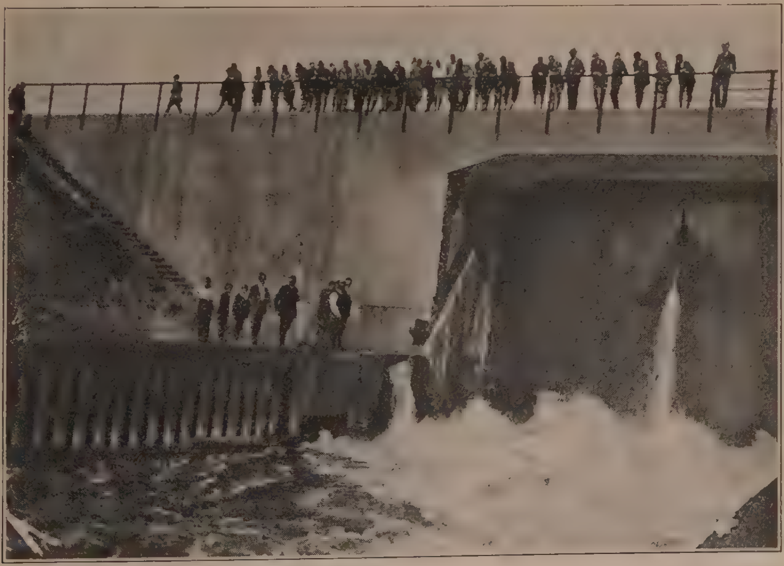


FIG. 46. — WIEBLINGEN LOCK ON RIVER NECKAR CANALIZATION (*Burkhardt*)

Downstream end — lock being emptied

summer (1927) differing completely from the usual type of locks. The lock is built according to the design of *Dr. Burkhardt* of Stuttgart. It is 110 meters long, 12 meters broad, and has a drop of 10 meters.

Fig. 41 indicates that if a partition wall is placed just below the sill the eddies forming between this partition and the drop wall will dissipate the energy almost completely.

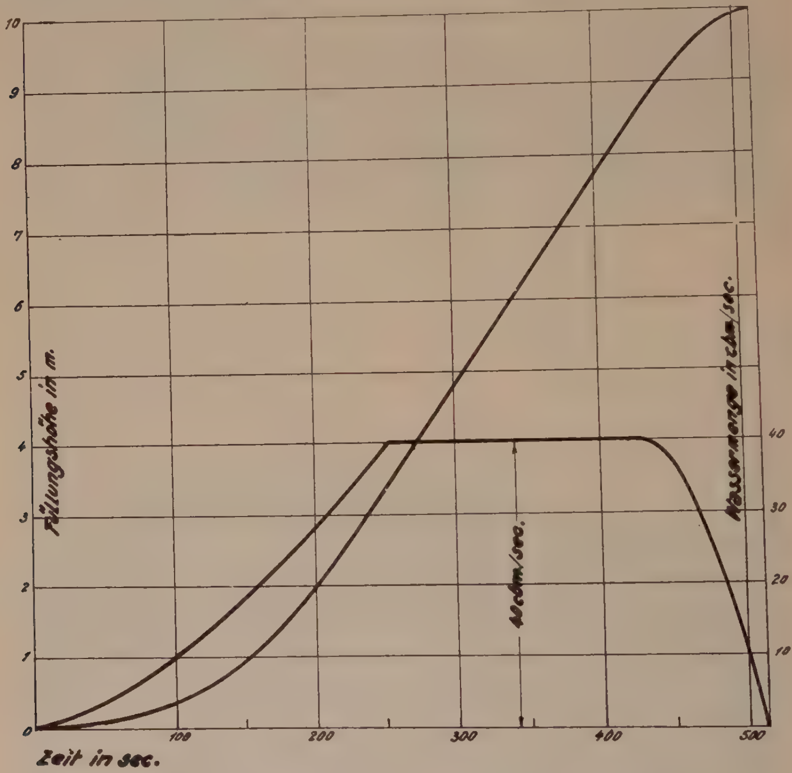
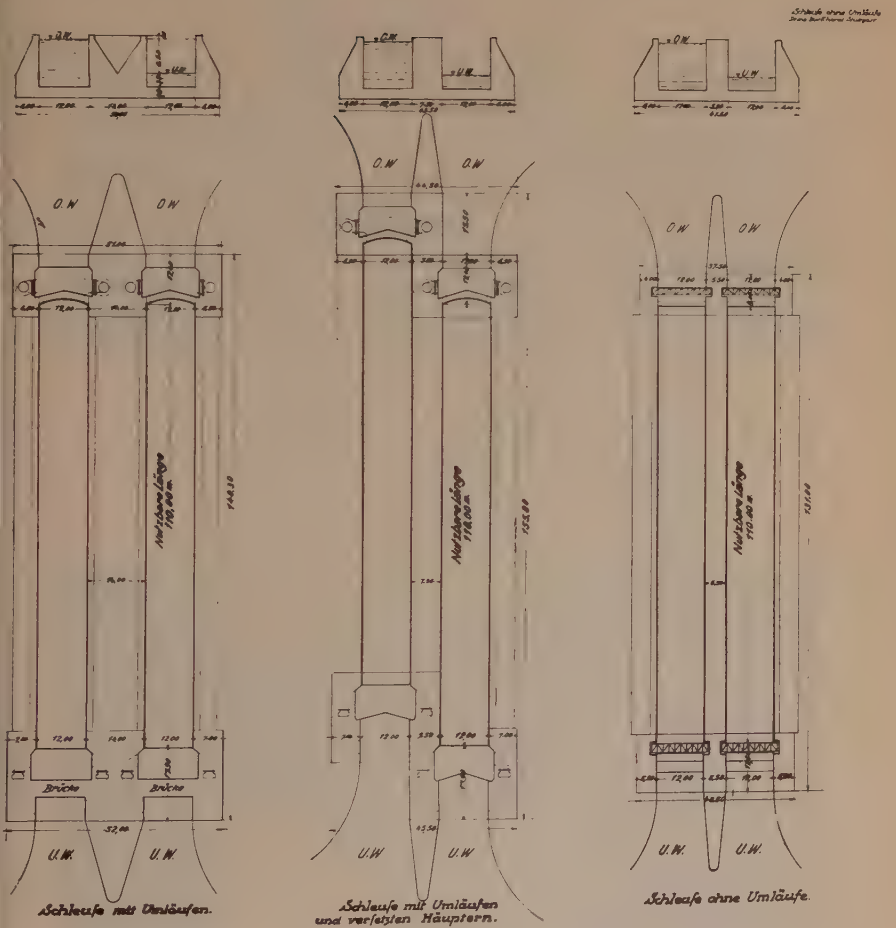


FIG. 47. — DIAGRAM OF LOCK DISCHARGE (*Burkhardt*)

Füllungshöhe = water level when lock is being filled
Wassermenge = rate of discharge
Zeit = time

Figs. 42 and 43 show that a horizontal grating brings the eddy higher up so that no wave action is observed in the lock chamber from downstream level to higher levels in the lock. The use of a dentated sill gave no results.

At the downstream end lifting gates are also employed, and although the outgoing flow does not influence the boat in the lock, it was thought



Schleufe mit Umläufen.

Schleufe mit Umläufen und verfetzten Häuptern.

Schleufe ohne Umläufe.

Fig. 48. — Comparison of Twin Locks Old and New Types (*Burkhardt*)

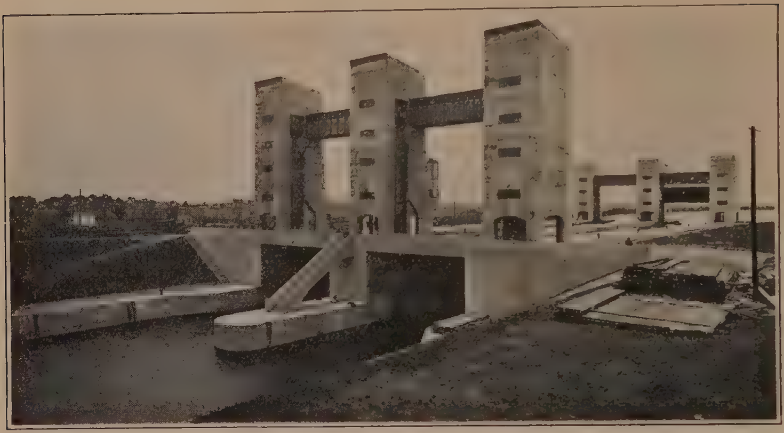


FIG. 49. — LADENBURG LOCK ON RIVER NECKAR CANALIZATION (*Burkhardt*)
General view looking upstream

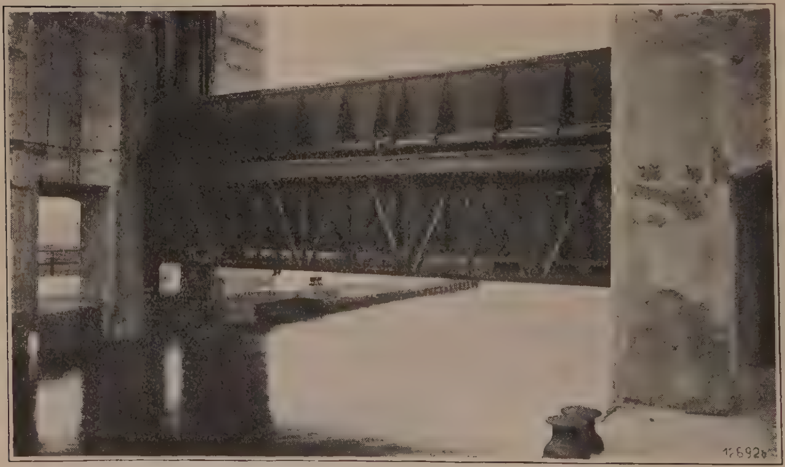


FIG. 50. — LADENBURG LOCK ON RIVER NECKAR CANALIZATION
Lifting gate at upper end (*Krupp-Gruson*)

necessary to introduce a chamber for dissipating the energy beneath the sill of the lower gate.

Fig. 44 shows the design at the downstream end in order to avoid heavy scouring below the lock such as took place at the lock of Wieblingen on the same canal built under the old system.

Fig. 45 shows the Ladenburg Lock (built with improved design of downstream end) being emptied. *Fig. 46* shows the turbulence at the downstream end when the Wieblingen Lock (old type) is being emptied.

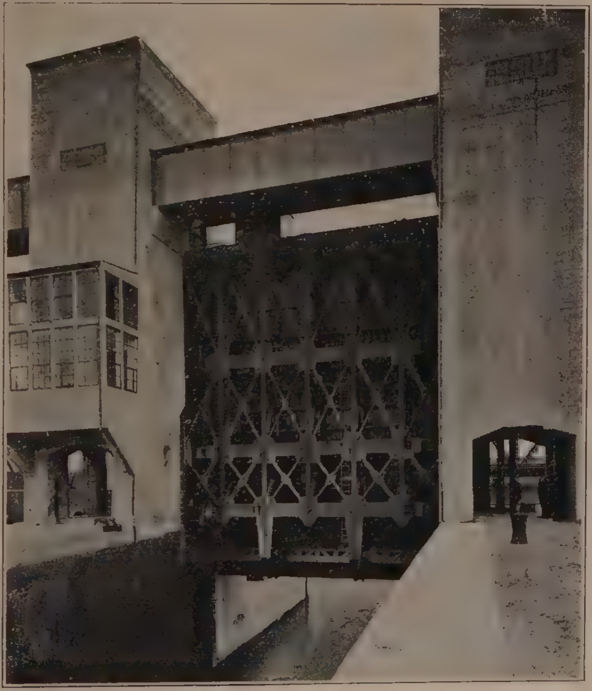


Fig. 51.—Ladenburg Lock on River Neckar Canalization

Lifting gate at lower end (*Krupp-Gruson*)

Fig. 47 shows a diagram of the discharge (maximum 40 cubic meters per second) and a curve of level in the lock chamber which is filled up to summit level 10 meters above downstream level in 500 seconds (=8 minutes 20 seconds).

Fig. 48 shows the improvement in the lock construction according to *Dr. Burkhardt's* design, as compared with the old system. Economy of 3 meters in length and 5 meters in width at the upstream end and 5 meters in length and 5 meters in width at downstream end is obtained with a resulting economy in masonry of 50 per cent at upper end and 25 per cent at lower end.

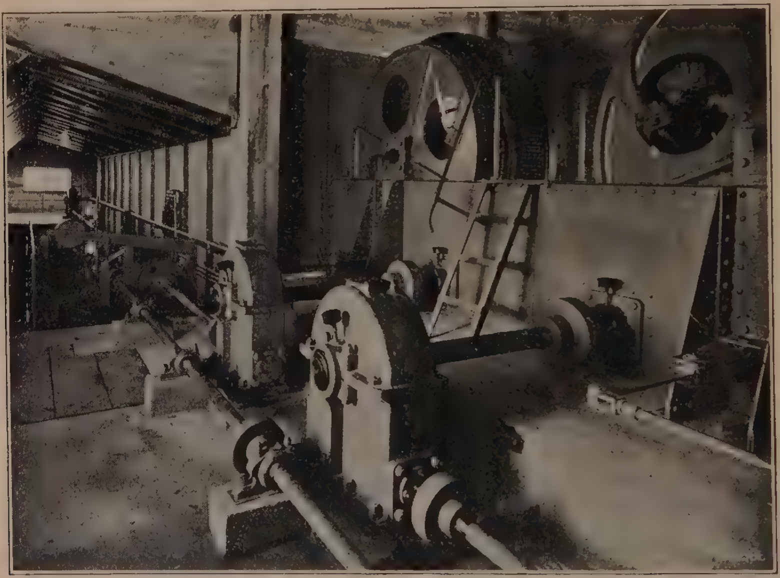


Fig. 52. — Ladenburg Lock on River Neckar Canalization

Machinery for lifting upstream gate (*Krupp-Gruson*)

Figs. 49, 50, 51 and 52 show details of lifting gates according to the design of the firm *Krupp-Gruson*, Magdeburg.

Although the foregoing is but a brief summary of the scientific work done in the German hydraulic laboratories, it may serve to indicate that they have contributed much more to the advancement of knowledge of hydraulics than has abstract theory.

OF GENERAL INTEREST

GEOLOGY IN THE MAKING

Erosion of a Canyon in One Night — The Work of the Flood at Cavendish, Vermont *

By Irving B. Crosby †

A canyon over 50 feet deep and half a mile long *made in one night!* This ounds like a fairy story, but to the eople of Cavendish, Vermont, it is a ragic reality. One day there was a leasant street dotted with comfortable omes, and the next morning found a awning canyon with seven homes gone nd others tottering on the brink. Not only had the seven houses with their barns and garages, some seventeen buildings in all, been swept away, but the land they formerly stood on had disappeared and in its place was a jagged gulch.

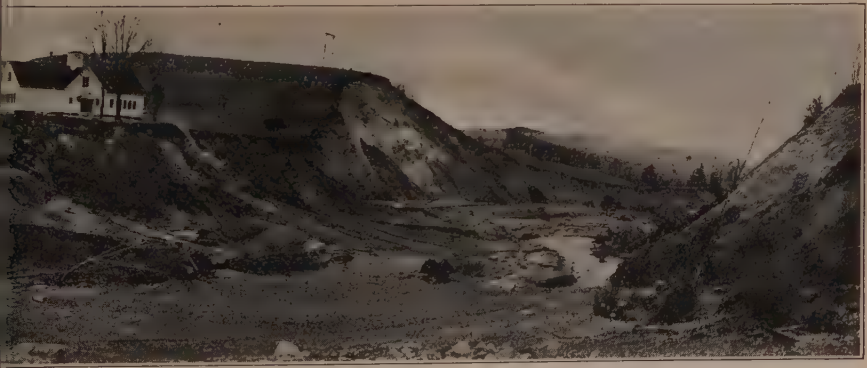


Photo by H. A. Boss, Ludlow, Vermont.

FIG. 1. — CANYON CUT BY FLOOD AT CAVENDISH, VERMONT

Hundreds of thousands of cubic yards of material had been removed and a spectacular geological feature created, not during the slow course of many centuries, but in a few hours. A mile down the valley valuable farm land had been buried under gravel and other débris, thus constituting another geologic change. Erosion and deposition had taken place on a large scale in one night.

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* See, also, Jacobs, E. C., "Flood Erosion at Cavendish, Vermont." Science, Vol. 66, pp. 653, 654, 27.

† Consulting Geologist, Boston, Mass.

The situation at Cavendish was peculiar. The village is located on the Black River and the Rutland Railroad, at a distance of 22 miles from Bellows Falls, at an elevation of about 900 feet above sea level. The Black River flows down a broad, nearly level valley from Proctorsville, one and a half miles to the west. At the close of the glacial period the ice stood just east of Cavendish, and sediments washed from the ice were deposited in a glacial lake, thus forming the flat valley floor on which the village now stands. The preglacial course of the river was buried under sand, and it cut a new channel in the ledge at the south side of the valley. At the eastern end of the village of Cavendish the valley is blocked by a sand ridge which connects with a rock hill on the south. There was a narrow gap through the ridge north of the rock hill. The Black River flows through a deep gorge on the south side of the hill. Twenty years ago a dam and power house were built in the gorge.

On the evening of November 3 the river rose, flooding the lower end of the village, and at 10 o'clock started flowing through the gap, thus taking a short cut to its channel below the dam. In making this short cut the overflow dropped 180 feet, which gave it great velocity. It soon began cutting down rapidly, and at five minutes of 1 on the morning of the 4th the first house was washed out. In twenty-five minutes three houses went, and by 4 A.M. seven houses with their outbuildings had gone. The torrent was rapidly working back into the center of the town, but fortunately it cut down upon ledge, which prevented its wearing farther back, and thus saved the remainder of the town. When the flood subsided the water withdrew into its natural channel and left a gaping canyon. Seven families had lost their homes and the main road to the east from the town was swept away, but happily no lives were lost, though two women were taken out of their house only ten minutes before the house was destroyed.

The flood waters swept down the slope and rejoined the Black River at a lower level below the rock hill and the dam. A mile farther down, at Whitesville, the torrent slackened and deposited its load of débris, burying a farm under gravel and causing more loss.

The greatest down-cutting by the torrent was about 50 feet, but where it went through the sand ridge it eroded laterally, tearing away the ends of the ridge on either side, thus leaving ragged bluffs about 150 feet high. The total length of the gulch is perhaps half a mile.

This disaster is a forceful demonstration of the power of running water. Here it had great velocity, large volume and soft materials to work upon, and the results are almost unbelievable. At time of low water the Black River, like many others, gives little evidence of its ability to erode, but in flood it has amazed us with its power. Similar but less spectacular instances may be found everywhere, and it seems probable that much of the erosion of which we see evidence has occurred in times of flood. It is not safe to refer all cases of erosion to the distant past and consider that they have taken a very long time. This is especially true where we are dealing with unconsolidated sands and clays. At Cavendish the torrent which tore away the sand so easily had no appreciable effect on the ledge.

Evidence collected in Cavendish from those who had lost their homes and seen the disaster makes it seem probable that had there been any one present who was familiar with the power of running water the calamity which befell part of the village might have been averted. When the water first flowed through the gap it was probably a mere trickle, and a few men could have quickly thrown up a dike and prevented it from getting a start, but lacking this control the trickle rapidly cut down, drew more water from the river, and soon became a raging torrent which nothing could stem.

Undoubtedly there are other places in New England where unusual flood conditions may lead to a disaster but which can be prevented if they are foreseen in time.

Freeman Fund Travelling Scholarship

Announcement was made in the September JOURNAL that Kenneth C. Reynolds, Instructor in Civil Engineering at Massachusetts Institute of Technology, had been awarded the John R. Freeman Travelling Scholarship of the Boston Society of Civil Engineers, which provides for a year's study and work in the European Hydraulic Laboratories. Scholarships of this character were also made available in the American Society of Civil Engineers and the American Society of Mechanical Engineers through the generosity of Mr. Freeman in establishing similar funds in those two societies. In addition, the Massachusetts Institute of Technology provided a graduate scholarship for a year's study abroad. At present the following men are in Europe under these auspices: K. C. Reynolds, from the Boston Society of Civil Engineers; L. G. Straub and F. T. Mavis of the University of Illinois and M. P. O'Brien of Purdue University, from the American Society of Civil Engineers; H. N. Eaton of the United States Bureau of Standards and B. R. Vanleer of the University of California, from the American Society of Mechanical Engineers; and J. B. Drisko, from the Massachusetts Institute of Technology.

In order that the members of the Society may have an idea of the work undertaken by the holders of these scholarships, the following brief summary is given of Mr. Reynolds' activities since leaving the United States in July, 1927:

Berlin. — Scholarship holders assembled at Berlin in August and took special classes to perfect conversational German. While here Mr. Freeman conducted them on an inspection trip to the Prussian Experimental Institution for Hydraulic Engineering and Shipbuilding in Berlin.

Danzig. — Late in August they went to the Technische Hochschule in Danzig, where Dr. Winkel gave a series of lectures on "The Laws of Hydraulic Similitude." Mr. Reynolds remained here until the end of September, his time being occupied by Dr. Winkel's lectures and by work in the river-hydraulic laboratory, observing and assisting in experimental work, and collecting data on the laboratory and its apparatus.

Karlsruhe. — Since the beginning of October, Mr. Reynolds and some of the others have been at the Technische Hochschule at Karlsruhe (Berlin) under the guidance of Professor Rehbock. The river-hydraulic laboratory at Karlsruhe is one of the largest laboratories devoted to river-flow studies in the world. This building was erected in 1920 and contains 22 experimental units. In addition to experimental work, lectures were attended given by Professor Rehbock on hydraulics, harbors and ship canals, by Dr. Boss on hydraulic computations, and by Professor Spannhake on hydraulic turbines and the laws of motion of water. While at Karlsruhe, a hydro-electric plant (the Murg-Schwarzenbach) was inspected, a description and report of which has been made by Mr. Reynolds. Much time has been devoted to actual experimentation work in the laboratory at Karlsruhe, and many problems are being studied, including the use of an indented sill on a dam to reduce scour at the toe and downstream; design of bridge piers to reduce scour in a river; precise weir measurements; tests to determine length of aprons on dams; and various problems of river regulation, canalization, etc.

While it is not feasible to give further details of this work, enough has been presented to show the practical way in which these holders of the John R. Freeman Travelling Scholarships are at work. The co-operation given by the men in charge of these laboratories is excellent, and is of the greatest assistance in enabling Mr. Reynolds and his colleagues to receive authoritative information.

It is of particular interest to note that this issue of the JOURNAL contains an extensive article on the European Hydraulic Laboratories by Dr. George H. de Thierry of the Technical University of Charlottenburg, Germany. Dr. de Thierry presented this paper before the Boston Society of Civil Engineers on April 28, 1927, when he was in the United States at the invitation of the Massachusetts Institute of Technology, where he gave a series of lectures on these hydraulic laboratories and on the work which they were accomplishing.

Colonel Boyden's Address Available

On November 16, 1927, Col. H. C. Boyden, Lecturer for the Celite Products Company of Los Angeles, California, gave an illustrated talk at a Joint Meeting of the Boston Society of Civil Engineers and the Northeastern Section, American Society of Civil Engineers, on "Workability in Concrete with Particular Reference to the Use of Diatomaceous Silica."

Colonel Boyden's address has now been published by the Celite Products Company, and copies may be obtained by request from the Boston Society of Civil Engineers, 715 Tremont Temple, Boston. This paper is published in a convenient form (8½" x 11") and contains twenty-five photographs and diagrams, illustrating the important features discussed by him at the November meeting.

MEMOIR

Edward Augustus White Hammatt *

DIED MARCH 18, 1927

EDWARD AUGUSTUS WHITE HAMMATT, son of Samuel Parkman and Maria (White) Hammatt, was born in that part of West Cambridge which is now Belmont, on September 30, 1854, and received his early education in the public schools of that place. Later he entered the Massachusetts Institute of Technology from which he was graduated in the class of 1875. After graduation he was engaged as follows: 1875, rodman on preliminary railroad survey; 1876, rodman, Newton Water Works, and assistant engineer with J. P. Frizell; 1877, miscellaneous work; 1878, draftsman, Lewiston Water Works, Lewiston, Me., and assistant engineer, New York & New England Railroad; 1879–80, draftsman, American Tool and Machine Company, and Boston Bridge Works; 1880–82, assistant engineer for Proprietors of

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* Memoir prepared by George Bowers and E. S. Dorr.

Locks and Canals on Merrimack River, Lowell, Mass.; 1882–85, chief assistant engineer with M. M. Tidd, mostly on waterworks construction at Marlborough, Hudson, Weymouth, Holbrook, Randolph, and Hyde Park in Massachusetts, and Gardiner, Me. In 1883 Mr. Hammatt opened an office in Boston as civil engineer, and, besides the ordinary work coming to such an office, he designed and built several sewer systems, and did considerable topographical and hydrographical work, and work for power development projects. In 1891 he opened a branch office in Hyde Park, Mass., doing the town work.

In 1906 he went with Charles T. Main and a party of engineers on an expedition to the Arros River in Mexico to investigate a hydro-electric development project for furnishing electric current to mining camps in northern Mexico and Arizona, and to select a site for a dam, head works, etc. Here Mr. Hammatt was left in charge and remained for about thirty days, doing, as he said, the hardest piece of work he ever attempted.

He found numerous dam sites with heads varying from 70 to 285 feet. Owing, however, to lack of provisions and time, and its great expense, the project was temporarily abandoned.

On October 16, 1882, he married Mary Louise Fifield, by whom he had four children — Richard Fox, Francis Parkman, Robert Wallace and Alice Louise. In 1912 he moved to Newton Center, and in 1916 to South Orleans, Mass.

The class of 1875, M. I. T., of which Mr. Hammatt was secretary-treasurer and historian for forty-two years, met and passed a set of resolutions, expressing their grief at the loss of their classmate, and sympathy for his family.

Mr. Hammatt became a member of the Boston Society of Civil Engineers on February 18, 1885. He was also a member of the American Society of Civil Engineers, the New England Water Works Association, and the Masonic Fraternity.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Designers Section

January 11, 1928. — The meeting was called to order at 6.05 p.m. by the chairman of the Section. The reading of the minutes of the previous meeting was omitted because they had already been published in the Journal.

Four speakers discussed various topics pertaining to the new Cottage Farm bridge. Mr. Lewis E. Moore, Consulting Engineer, described the methods he had used in designing the bridge. Mr. Andrew Canzanelli, of the Metropolitan District Commission, was concerned with the preliminary investigations and efforts, and with construction problems. Mr. Beardsley Lawrence, of T. Stuart & Son Company, contractors, told about the builder's operations. Mr. Benjamin Fink described some of the details of the design. Lantern slides were used.

The meeting of sixty-five members and guests was adjourned at 8.25 p.m.

Norman P. Randlett, *Clerk*.

Sanitary Section

December 7, 1927. — A meeting of the Sanitary Section was held in the Library of the Affiliated Technical Societies on Wednesday, December 7, 1927. At the dinner, which was informally held at Marston's preceding the meeting of the Section, there were twenty-seven present.

The Section meeting was called to order at 7.15 by the Chairman. Reading of the minutes for the preceding meeting was omitted.

The Chairman introduced the president of the Boston Society of Civil Engineers, Mr. Frank A. Marston of Metcalf & Eddy, who spoke with regard to recent developments in sewage treatment abroad. Mr. Marston's talk was based upon his observations in Europe during the past summer, and was illustrated with numerous lantern slides. Mr. Marston spoke particularly with regard to recent developments upon sewage treatment in Great Britain, Holland and Germany.

There were fifty-eight present at the meeting.

The meeting adjourned at 9.15 P.M.

R. W. HORNE, *Clerk.*

APPLICATIONS FOR MEMBERSHIP

[January 20, 1928]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

ABBOT, CHARLES BENJAMIN, Wayland, Mass. (Age 35, b. Berlin, Germany.) Graduate of Harvard University with B.S. in civil engineering. Experience: designer and draftsman, bridge office, Wisconsin State Highway Commission, 1921–23; structural designer, construction division, Stone & Webster, Inc., 1923 to date. Refers to *S. K. Cohen, J. A. Howe, C. E. Nichols, R. G. Stafford.*

ALLEN, HOWARD FRANCIS, Boston, Mass. (Age 21, b. Brockton, Mass.) Student at Northeastern University. During co-operative periods employed as rodman and chief of party by George Clements, Hyannis; ten weeks by Mr. White, Braintree; five weeks by Erie Railroad, New Jersey; sixteen weeks by Turner Construction Company; and six weeks by Mr. Hayward, Taunton. Refers to *W. J. Alcott, Jr., C. O. Baird, Jr., G. A. Haskins, A. M. Pillsbury.*

ALLEN, OTIS DYER, Watertown, Mass. (Age 48, b. Abington, Mass.) Experience: 1896–1923, with H. F. Bryant, Brookline; 1923–26, with American Woolen Company; 1926 to date, town engineer, Watertown. Refers to *H. F. Bryant, C. F. Knowlton, W. F. Learned, F. J. Maynard, H. A. Varney.*

BELKNAP, JOHN BALCOM, Framingham, Mass. (Age 21, b. Framingham, Mass.) Student at Tufts College, now in senior class. Refers to *Robinson Abbott, H. P. Burden, C. H. Holmberg, F. N. Weaver, E. H. Wright.*

BIGGART, WILLIAM LANG, Needham, Mass. (Age 39, b. Bloomfield, N. J.) Graduate of Cornell University in 1912. Experience: three and one-half years engineering assistant in county engineer's office, Newark, N. J.; two and one-half years Coastal Air Station and Norfolk, Va., Naval Base Piers and Bulkheads; one year engineering construction of 137 houses for Scovill Manufacturing Company, Waterbury, Conn.; one year with Turner Construction Company, industrial building; two years with United States Housing Corporation, 576 houses; three years with New York Telephone Company, as engineering assistant on switch board studies and recommendations for additional manual equipment; two years with Public Service Production Company, N. J., cost engineer, construction of complete water-gas plant. Refers to *E. H. Cameron, W. D. Henderson, H. B. Perry, W. H. Smart.*

Blumberg, Morris G., Brookline, Mass. (Age 47, b. Liverpool, Eng.) Experience: mechanical draftsman, 1900–06; structural draftsman, detail checking, designing, 1906 to date. With Purdy & Henderson, nine and one-half years; with New England Structural Company, ten and one-half years; with Stone & Webster, Inc., one year. Refers to *R. E. Baker, S. K. Cohen, L. S. Cowles, J. A. Howe.*

Booth, Ralph D., Salem, N. H. (Age 28, b. Methuen, Mass.) Graduate of Massachusetts Institute of Technology, 1920, with B.S. in electrical engineering. Experience: entered the employ of Public Service Corporation of New Jersey as assistant engineer, 1920; in October, 1920, entered the employ of Jackson & Moreland as assistant engineer, and has had responsible charge of design and construction of substations, power stations and trolley and transmission lines; at present is executive engineer. Refers to *E. H. Cameron, W. D. Henderson, D. C. Jackson, W. R. McCann, E. L. Moreland, I. E. Moultrop.*

Boyer, Richard Porter, Newton, Mass. (Age 43, b. Lost Creek, Pa.) Graduate of Harvard University, 1907. Spent one summer at Harvard Engineering Camp, Squam Lake, N. H. 1910–11 was contractor's engineer for Glyndon Contracting Company, on Catskill Aqueduct; 1912–15, with Lockwood, Greene & Co., in various capacities, — in drafting room, as resident engineer on mill construction, in charge of contract department, and in industrial appraisal work; 1927 to date, with Jackson & Moreland on appraisal of public utilities. Refers to *E. H. Cameron, W. D. Henderson, E. L. Moreland, H. B. Perry.*

Bradford, John Drake, Lynn, Mass. (Age 22, b. Lynn, Mass.) Is a student at Northeastern University. Has worked three years at general surveying and is at present assistant instructor in Northeastern University. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls.*

Brittain, James Frederick, Arlington, Mass. (Age 29, b. Medford, Mass.) Graduate of Massachusetts Institute of Technology. July, 1922, to June, 1923, assistant in civil engineering at Massachusetts Institute of Technology; June, 1923, to February, 1925, draftsman and inspector for Weston & Sampson; February 1, 1925, to May 1, 1927, assistant engineer in designing division of the Water Supply Board, Providence, R. I.; May 1, 1927, to date, assistant engineer with the Metropolitan District Water Supply Commission. Refers to *J. B. Babcock, G. G. Bogren, R. S. Holmgren, T. H. Safford, G. A. Sampson.*

Brooks, Samuel W., Everett, Mass. (Age 23, b. Freeport, N. S.) Graduate of Massachusetts Institute of Technology, 1926. From June, 1926, to November, same year, employed by J. R. Worcester & Co., as resident engineer on a reinforced concrete highway bridge; November, 1926, to May 1, 1927, on lines and grades and in field purchasing department, Turner Construction Company; May 1, 1927, to date, sales engineer for Celite Products Company. Refers to *J. B. Babcock, M. N. Clair, E. E. Pettee, C. M. Spofford.*

Bury, Albert Wallace, Brookline, Mass. (Age 24, b. New Bedford, Mass.) Is a senior at Northeastern University. During co-operative periods employed by United Electric Street Railway, Providence, R. I.; G. F. Clements, Hyannis, as instrumentman and chief of party; rodman, levelman and inspector by Erie Railroad. Refers to *H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

Carhart, Frank Milton, Wellesley Hills, Mass. (Age 45, b. Ogden, Utah.) Graduate of Massachusetts Institute of Technology, 1905, with B.S. in civil engineering 1905–08, miscellaneous work as instrumentman, draftsman and designer on railroad, irrigation and power projects in the Northwest; 1908–10, assistant state engineer of Idaho; 1910–13, chief engineer, Carey Act Department, State of Idaho, supervising design and construction of irrigation projects; 1913–18, special engineer, Southern Idaho Water Power; 1918–22, valuation engineer, Idaho Power Company; 1922–23, consulting engineer on intangibles and overheads for valuation of property of Pennsylvania Power and Light Company; 1923 to date, department head, Jackson & Moreland, in charge of appraisals, rate investigations and operating studies for both public utilities and industrial corporations. Refers to *W. D. Henderson, D. C. Jackson, E. L. Moreland, W. F. Uhl.*

CARNEY, JOSEPH PATRICK, Cambridge, Mass. (Age 21, b. Cambridge, Mass.) Graduate of Cambridge Latin School in 1924 and entered Franklin Union evening school, and at the end of a three-year course received a certificate in surveying. In July, 1924, entered engineering department, city of Cambridge, as a rodman, and in about a year became a transitman. Is at present instrumentman for engineering department, Cambridge. Refers to *R. L. Coolidge, E. W. Davis, L. M. Hastings, G. F. Hooker, W. M. Smith.*

CHASE, RUSSELL CUSHING, Stoneham, Mass. (Age 20, b. Dorchester, Mass.) Student at Northeastern University. During co-operative periods has been employed by city of Medford in engineering department, and Standard Oil Company on construction. Refers to *W. J. Alcott, Jr., C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

COBURN, CHARLES L., Lexington, Mass. (Age 32, b. Lexington, Mass.) Graduate of Massachusetts Institute of Technology, 1917. Experience as ship draftsman, Boston Navy Yard, July to December, 1917; ensign, Construction Corps, United States Naval Academy, Annapolis, Md., from December, 1917, to January, 1918; from January, 1918, to February, 1919, in Navy Yard, Puget Sound, Wash., principally as assistant to outside superintendent in charge of repair work, docking, etc., also had charge of personnel for latter part of period; released from active duty March, 1919; from April, 1919, to November, 1922, assistant engineer, Water Supply Board, city of Providence; November, 1922, to November, 1926, concrete designer, Stone & Webster, Inc.; from November, 1926, to date, assistant engineer for Metropolitan District Water Supply Commission. Refers to *J. B. Babcock, R. S. Holmgren, K. R. Kennison, T. H. Safford, F. E. Winsor.*

COFFIN, GEORGE WHEELER, Dorchester, Mass. (Age 30, b. Boston, Mass.) September, 1916, to June, 1918, in Massachusetts Institute of Technology, also January, 1919, to June; spring of 1918, enlisted in United States Naval Reserves; July, 1919, to June, 1920, installed water system for country estate and superintended building a four-room house; July, 1920, to March, 1921, assistant engineer with Boston & Montana Mining Corporation; April, 1921, and May, traveled through the Northwest and Pacific coast; June, 1921, to June, 1922, University of California, electrical engineering; August, 1922, to August, 1926, Engineering Division, Department of Public Health, State of Massachusetts; August, 1926, to December, general assistant and estimator, George M. Bryne, contractor; January, 1927, to March, shop work at home on apparatus for Massachusetts Department of Public Health; June, 1927, to date, assistant engineer, Metropolitan District Water Supply Commission. Refers to *R. S. Holmgren, T. H. Safford, A. D. Weston, Edward Wright.*

COLBY, WILBUR SANDERSON, Salem, Mass. (Age 26, b. Beverly, Mass.) Graduate of Massachusetts Institute of Technology, 1925. From June, 1925, to date, employed by Stone & Webster, Inc., as structural draftsman. Refers to *S. K. Cohen, J. A. Howe, J. C. Nowell, Jr., R. G. Stafford.*

COLVIN, ARTHUR E., Woburn, Mass. (Age 20, b. Woburn, Mass.) Student at Northeastern University. During co-operative periods has been employed by C. H. Gannett Company, and during summer vacations with the engineering department, city of Melrose. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls, W. E. Nightingale.*

CONDON, EUGENE BERNARD, Roslindale, Mass. (Age 20, b. Roxbury, Mass.) He is a student at Northeastern University. During the co-operative periods has been employed in engineering department, town of Milton. Refers to *H. B. Alvord,* *C. S. Ell, G. B. Gee, J. W. Ingalls, W. E. Nightingale, G. N. Watson.*

Corcoran, Arthur A., Medford, Mass. (Age 25, b. Boston, Mass.) Graduate of Northeastern University in civil engineering in 1922. Was in the employ of Stone & Webster, Inc., in the capacity of resident engineer from 1922 to 1927; from March, 1927, to August with Beacon Oil Company, as field engineer and draftsman; from August, 1927, to December with Stone & Webster, Inc., as a structural steel detailer; at present with the Beacon Oil Company as field engineer and structural designer. Refers to *S. K. Cohen, J. A. Howe, J. C. Nowell, Jr., R. G. Stafford.*

Cosgrove, Frank H., Worcester, Mass. (Age 23, b. Worcester, Mass.) Graduate of Worcester Polytechnic Institute in 1926. With Stone & Webster, Inc., as structural draftsman. Refers to *C. M. Allen, S. K. Cohen, J. A. Howe, J. C. Nowell, Jr.*

Custer, William Clarke, Arlington, Mass. (Age 23, b. Somerville, Mass.) Graduate of Tufts College, Engineering School, in June, 1926, with degree of B.S. in civil engineering. While in college worked three summers for the Massachusetts Highway Commission; soon after graduation employed by the Concrete Steel Company, drafting and designing on reinforced concrete; from August, 1927, to date, structural engineer with Barker Steel Company. Refers to *H. P. Burden, T. R. Lyons, E. D. Mortenson, F. N. Weaver.*

Damon, John C., Boston, Mass. (Age 45, b. Concord, Mass.) Graduate of Massachusetts Institute of Technology, 1905, electrical engineering. Experience: 1912–17, with Electric Bond and Share Company; 1918, United States Army; 1919–22, West Lynn Power Company; 1923–24, Stone & Webster, Inc.; 1924–27, with the American Brass Company; 1927, to date, with Jackson & Moreland. Refers to *E. H. Cameron, W. D. Henderson, H. B. Perry, W. H. Smart.*

Davis, Almon Charlie, N. Springfield, Vt. (Age 21, b. Charlestown, N. H.) Student at Northeastern University. During co-operative periods has been employed by Sherman Power Construction Company, Worcester, on power development of Bellows Falls, Vt. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls.*

Deacon, Malcolm Edgar, West Medford, Mass. (Age 25, b. Pittsfield, Mass.) Student of Northeastern University. During co-operative periods employed by city of Newton as rodman; McClintock & Woodfall, as sewer inspector; chainman, by Boston & Maine Railroad; chainman, by New York, New Haven & Hartford Railroad; McClintock & Woodfall, as chief of party and draftsman. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls, A. Q. Robinson.*

Fitz, Henry I., Boston, Mass. (Age 24, b. York, Pa.) Graduate of Lafayette College in 1925; since then has been with Stone & Webster, Inc., as steel designer. Refers to *S. K. Cohen, H. P. Fessenden, J. A. Howe, J. C. Nowell, Jr.*

Fraser, Dean Blenus, Brockton, Mass. (Age 37, b. Charlestown, Mass.) Graduate of Rhode Island State College in 1916, with degree B.S. in civil engineering. Experience: June, 1916, to February, 1917, rodman, maintenance of way department, New York, New Haven & Hartford Railroad; February, 1917, to May, same year, draftsman, Turner Construction Company; May, 1917, to May, 1919, Second Lieutenant, Air Service, United States Army; May, 1919, to date, draftsman, construction engineer and estimator, Turner Construction Company. Refers to *O. D. Chiesa, R. W. Kent, T. R. Lyons, A. C. Tozzer.*

Freeman, Raymond Allison, Boston, Mass. (Age 22, b. Brooklyn, N. Y.) Graduate of Massachusetts Institute of Technology, 1926. From June, 1926, to February, 1927, was transitman for D. P. Robinson; February, 1927, to date, junior engineer, with Jackson & Moreland. Refers to *E. H. Cameron, W. D. Henderson, W. H. Smart, Hale Sutherland.*

Gates, Edwin B., Brookline, Mass. (Age 21, b. Orange, Mass.) Student at Northeastern University. During co-operative periods has been employed in the engineering department of Boston & Maine, by city engineer of Newton, and Turner Construction Company. Refers to

W. J. Alcott, Jr., C. S. Ell, J. W. Ingalls, E. V. Lewis, V. N. Norcross.

GENASKE, ALBERT, Chestnut Hill, Mass. (Age 29, b. Ashmont, Mass.) Graduate of Massachusetts Institute of Technology, 1921. Experience: eighteen months as assistant engineer with New England Power Company; September, 1925, to November, 1926, with City Planning Board, Boston; November, 1926, to date, assistant engineer, with Metropolitan District Water Supply Commission. Refers to *J. B. Babcock, R. S. Holmgren, K. R. Kennison, T. H. Safford, F. E. Winsor.*

GENTLEMAN, LAWRENCE MILES, Watertown, Mass. (Age 29, b. Kezar Falls, Maine.) Graduate of Massachusetts Institute of Technology, 1922. From June, 1922, to June, 1923, assistant in civil engineering department, M. I. T.; June, 1923, to February, 1925, draftsman, Stone & Webster, Inc.; February, 1925, to April, 1926, assistant engineer in designing division, Water Supply Board, Providence; April, 1926, to January, 1927, concrete designer, Stone & Webster, Inc.; January, 1927, to date, assistant engineer, designing division, Metropolitan District Water Supply Commission. Refers to *J. B. Babcock, R. S. Holmgren, W. F. Learned, C. M. Spofford, F. E. Winsor.*

GILLETTE, ERNEST H., Boston, Mass. (Age 36, b. Savona, N. Y.) Education: one year at Valparaiso University, Indiana; three years at University of Michigan. Experience: 1915–16, appraisal of public utilities with D. C. and W. B. Jackson; July, 1916, to March, 1919, with Stone & Webster, Inc., first in the Boston office, then at San Antonio in charge of estimating and drafting for army cantonment, then Washington, D. C., drafting on ammunition depot in France, Hog Island Ship Yard, drafting on concrete and timber structures; July, 1919, to September, same year, San Juan, Porto Rico, architectural drafting; October, 1919, to May, 1924, office engineer for The Barahona Company, Inc., in charge of drafting room; June, 1925, to May, 1927, with Aberthaw Company as checker on concrete and steel buildings; June, 1927, to date, with M. C. Tuttle Company, as draftsman. Refers to *J. A. Garrod, H. A. Gray, Erwin Harsch, A. R. Starrett.*

GOODEN, WILLIAM MAX, Wollaston, Mass. (Age 27, b. Edison, Neb.) Educated at Hastings College, 1917–19; University of Nebraska, 1920–21; University of Colorado, 1923–26. Experience: United States Bureau of Mines, Pittsburgh, as assistant mechanical engineer; city engineer's office, Hastings, Neb., drafting, surveys, estimates; April, 1920, to October, same year, Heimbecker Brothers, Denver; 1921–23, construction department, University of Colorado, in charge of construction and estimates; June, 1925, to date, with Stone & Webster, Inc., as designer, structural draftsman, then in administration department, and now designing structural draftsman. Refers to *R. E. Baker, S. K. Cohen, L. S. Cowles, J. A. Howe, J. C. Nowell, Jr.*

GUARINO, MARCELLO J., East Boston, Mass. (Age 20, b. White River Junction, Vt.) Is a junior at Northeastern University. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

HAMMATT, ABRAM CROSBY, Cambridge, Mass. (Age 25, b. Topeka, Kan.) Education: one and one-half years in Wisconsin University, two and one-half years at Massachusetts Institute of Technology. Since November, 1926, employed by Jackson & Moreland. Refers to *E. H. Cameron, W. D. Henderson, H. B. Perry, W. H. Smart.*

HATHAWAY, CARLTON WENTWORTH, Brookline, Mass. (Age 21, b. Little Compton, R. I.) Student at Northeastern University. During co-operative periods has been employed by M. E. Metcalf, New Bedford, as rodman from September, 1925, to September, 1926; as rodman for United Electric Street Railway, Providence, R. I.; and by the Erie Railroad Company of New York. Refers to *H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

HEANEY, FRANK, Braintree, Mass. (Age 19, b. Braintree, Mass.) Is a student at Northeastern University. During co-operative periods has been employed by Whitman & Howard as a rodman; by Hartley L. White as rodman mostly on highway surveys; by F. J. Maynard, as levelman and transit man; and recently with Metcalf & Eddy as draftsman. Refers to *C. O. Baird, C. S. Ell, F. L. Flood, J. W. Ingalls, F. A. Marston, W. E. Nightingale.*

Higgins, Stanley Allen, Lexington, Mass. (Age 30, b. Somerville, Mass.) Graduate of Massachusetts Institute of Technology. During the summer of 1923 did surveying, drafting and concrete construction for the Viscol Company of Cambridge. In December, 1924, was transitman with Lockwood, Greene & Co.; from January, 1925, was architectural appraiser for same company; from September, 1925, to June, 1926, was estimator on building materials for Wm. C. McConnell Company of Cambridge; from July, 1926, to April, 1927, was in engineering department of Boston & Albany Railroad as inspector of construction at Warren, Mass., and then as chief of survey party at Chatham, N.Y.; since April, 1927, assistant town engineer, Lexington, Mass. Refers to *J. B. Babcock, C. B. Breed, G. L. Hosmer, J. W. Howard, H. C. Thomas.*

Hilton, Roger R., Brookline, Mass. (Age 21, b. Berwick, Me.) Student at Northeastern University. During co-operative periods has been employed by J. J. Van Valkenburgh, surveying for water and sewer lines, standpipe construction, road surveys, filter bed surveys, etc. Refers to *W. J. Alcott, Jr., C. O. Baird, J. W. Ingalls, G. H. Meserve, Jr., W. E. Nightingale.*

Homkowycz, Theodore Wallace, Brighton, Mass. (Age 21, b. Meriden, Conn.) Student at Northeastern University. During co-operative periods has been employed by C. H. Gannett, and now with Aspinwall & Lincoln. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls.*

La Belle, Lionel, Brockton, Mass. (Age 20, b. Brockton, Mass.) Student at Northeastern University. During co-operative periods has been employed by city of Brockton, engineering department, and is still with them and rated as a transit man. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls, W. E. Nightingale.*

LaFauce, Joseph A., Somerville, Mass. (Age 21, b. Somerville, Mass.) Spent four years at Franklin Union, also took a correspondence course at State University Extension. Refers to *Robinson Abbott, E. A. Graustein, L. M. Hersum, E. A. Varney.*

Leonard, Harry Theodore, Milford, Mass. (Age 21, b. Rutland, Vt.) Student at Northeastern University. During co-operative periods has been employed by J. J. Van Valkenburgh, and is still working for him. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls.*

Lunsford, John A., Cambridge, Mass. (Age 27, b. Doans, Tex.) Graduate of University of Colorado in 1927, with degree B.S. Prior to graduation was employed as follows: 1923, by Phelps Dodge Corporation, as mining engineer; 1924, by the State Highway Department, as draftsman for a period of four months; from March, 1924, to August was employed by the Ray Consolidated Copper Company, as assistant; from August, 1924, to December, 1925, was instrumentman and draftsman for Southern Pacific Railroad; since graduation has been employed by Stone & Webster, Inc., as structural draftsman. Refers to *R. E. Baker, S. K. Cohen, J. A. Howe, R. G. Stafford.*

McGinness, William H., Cambridge, Mass. (Age 20, b. Cambridge, Mass.) Graduate of Rindge Technical School, 1923; completed a one-hundred-hour course in mathematics and physics at Franklin Union; also completed engineering course at the McDowell School of Arts; took a one-hundred-hour course in structural design at Franklin Union, a building course at Lowell Institute; 1923 to date, in the city engineer's office, Cambridge, and is now office assistant and transitman. Refers to *R. L. Coolidge, E. W. Davis, L. M. Hastings, G. F. Hooker, W. M. Smith.*

McIntosh, Otis William, Lynn, Mass. (Age 21, b. Revere, Mass.) Student at Northeastern University. During co-operative periods has been employed by Philip J. Leary, C.E., of Lynn. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls, W. E. Nightingale.*

Meehan, John Joseph, Jamaica Plain, Mass. (Age 24, b. Jamaica Plain, Mass.) Student at Northeastern University. During co-operative periods has been employed by the bridge and ferry division, city of Boston, as rodman and transitman. Refers to *H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

MEYER, FREDERICK W., Brighton, Mass. (Age 42, b. Diedenhofen, Germany.) Graduate of Engineering School, Strassbourg, Alsace. Experience: 1909, with state railway in Germany as draftsman for layout of freight terminal; 1910–15, with German government in West Africa as superintendent for general engineering and construction work; 1918–20, designing, drafting and administration work for general engineering in Germany; 1921–23, with Dutch government for overseas service at Java; 1923, with W. and L. Engineering Company, Cambridge, Mass., as engineer, building construction; 1924, with Stone & Webster, Inc., as designing draftsman for reinforced concrete; 1924–25, with Jenks & Ballou as designer and detailer for power plant construction; 1925–27, with Monks & Johnson as checker in structural engineering; 1927 to date, with Coolidge, Shepley, Bulfinch & Abbott, as structural engineer. Refers to *J. J. Harty, R. B. Miner, E. D. Mortenson, W. F. Pike, B. A. Rich.*

MEYERS, FRANK C., Boston, Mass. (Age 21, b. Allston, Mass.) Is a student at Northeastern University. During co-operative periods has been employed by Simpson Brothers Corporation, on National Relief maps. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

MOORE, DONALD E., Cambridge, Mass. (Age 26, b. Clarkston, Wash.) Graduate of Massachusetts Institute of Technology, 1924. Experience: one and a half years with Stone & Webster, Inc., on detail, design and construction; a year and a half with North American Cement Corporation, as sales engineer, specializing on concrete control. Refers to *J. B. Babcock, H. K. Barrows, M. N. Clair, C. M. Spofford.*

MORRILL, WILLIAM CHARLES, Brookline, Mass. (Age 21, b. Haverhill, Mass.) Student at Northeastern University. During co-operative periods has been employed by the Commonwealth of Massachusetts on highway and bridge construction as a draftsman and instrumentman. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls, W. E. Nightingale.*

MOZZICATO, JAMES SEBASTIAN, Medford, Mass. (Age 22, b. Cannicatinni Bagni, Italy.) Graduate of Lowell Institute, 1925; October, 1923, to November, 1925, laboratory assistant to Prof. R. H. Smith, Massachusetts Institute of Technology; November, 1924, to February, 1926, member of firm, Paul Curcio & Co., contractors, Watertown; February, 1926, to April, tool designer, Condit Electric Manufacturing Company; April, 1926, to August, 1927, estimator and engineer for William M. Bailey Company, contracting engineers; August, 1927, to date in contracting business. Refers to *H. W. Hayward, E. F. Miller, G. E. Russell, W. H. Smart.*

NELSON, VERNE O., Lynn, Mass. (Age 40, b. Provo, Utah.) Experience: chainman, Government Land Survey, Utah, 1910; 1912–21, instrumentman, inspector and location engineer, Lake Irrigation Company of Provo; 1922, office engineer, Salt Lake City; 1923–24, field engineer and office work, Columbia Steel Corp.; 1924–26, construction of complete blast furnace, buildings, tracks, canal, sewer and pipe lines, Mystic Iron Works; 1926–27, engineer of construction, Bay State Dredging Company. Refers to *J. J. Vertic, D. J. White, G. H. Whitney.*

NILAN, WILLIAM JOSEPH, Boston, Mass. (Age 21, b. New York, N. Y.) Student at Northeastern University. During co-operative periods is employed by New York, New Haven & Hartford Railroad. Refers to *W. J. Alcott, Jr., C. O. Baird, Jr., G. B. Gee, J. W. Ingalls.*

O'SHEA, BERNARD AUGUSTINE, Lynn, Mass. (Age 19, b. Lynn, Mass.) Student at Northeastern University. During co-operative periods has been employed by Aspinwall & Lincoln. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., J. W. Ingalls.*

PERRY, GEORGE NELSON, Waverley, Mass. (Age 22, b. Waltham, Mass.) He is a student at Northeastern University. During the co-operative periods he has been with Barnes & Beal as rodman, and this year is with town of Milton as transitman under F. J. Maynard. Refers to *W. J. Alcott, Jr., C. O. Baird, Jr., J. W. Ingalls, E. D. Mortenson.*

Pethybridge, Clarence Edward, Fitchburg, Mass. (Age 38, b. Rockville, Conn.) Experience: started as rodman for Bailey & Classon, Fitchburg; they sold to Fred C. Davis in 1909, and he continued with them until the spring of 1910, when he started working for the city of Fitchburg, — from 1911 to 1918; from 1918 to 1923 had no connection with engineering work; 1923, was on state road construction; 1924 to 1926, employed by Charles H. Davis, civil engineer in private engineering; from August, 1926, to date employed in Department of Public Works, Fitchburg. Refers to *H. B. Allen, F. W. Bateman, G. H. Chase, W. G. Classon.*

Potter, B. Arthur, Lynn, Mass. (Age 21, b. Lynn, Mass.) Student at Northeastern University. During co-operative periods has been employed by Essex County engineer. Refers to *H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

Prowse, Robert John, Brookline, Mass. (Age 21, b. Concord, N. H.) Student at Northeastern University. During co-operative periods has been employed by the city of Newton, engineering department. Refers to *H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, E. V. Lewis.*

Radzikowski, Henry Adam, South Boston, Mass. (Age 21, b. South Boston, Mass.) Is a senior at Tufts College. Refers to *Kingman Abbott, H. P. Burden, C. H. Holmberg, F. N. Weaver, E. H. Wright.*

Reed, Walter J., Milton, Mass. (Age 34, b. Hyde Park, Mass.) Educated in Pepperell High School and Franklin Union. Experience: superintendent of water supply, Henniker, N. H., 1914; inspector, Asby Reservoir, 1915; superintendent of Sewers, Reading, Mass., 1916; night superintendent, Squantum Plant, 1917; general superintendent, A. G. Tomasello & Son, 1918 to date. Refers to *D. A. Ambrose, W. H. Cronin, Thomas Mulcare, J. R. Rablin, J. D. Savage, J. A. Tomasello.*

Rice, Russell J., Needham, Mass. (Age 33, b. Brighton, Mass.) Graduate of Dartmouth College, 1915, with degree B.S.; Thayer School of Civil Engineering, 1916. Experience: 1917, estimator, Petroleum Iron Works Company; 1919, United States Army, Meteorological Division Signal Corps; 1920, assistant town engineer, Farrell, Pa.; 1921, plan examiner, city of Boston Building Department; at present assistant engineer, Turner Construction Company. Refers to *J. P. Snow, H. A. Symonds, A. C. Tozzer, H. A. Wilson.*

Rigo, Joseph Blanchfield, Boston, Mass. (Age 26, b. Portland, Me.) Student at Northeastern University. During co-operative periods has been employed as transitman, with John Dyer, Melrose; chief of party, George Clements, Hyannis; transitman and chief of party, by city of Portland; transitman, with Lewis W. Perkins, North Scituate; chainman, Boston & Albany Railroad. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

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Rusletvedt, Trygve, Milton Mass., (Age 39, b. Norway). Took building course at Lowell Institute, 1916; mechanical, electrical and concrete courses; University Extension, "Power Plant Economics." Experience: 1912–13, draftsman at Fore River Shipbuilding Corporation; 1913–17, draftsman and designer with B. F. Sturtevant Company; 1917–20, 1921–24, designer and chief draftsman, American Industrial Furnace Company; 1920–21, 1924–25, concrete designer, Stone & Webster, Inc.; 1925–27, chief draftsman, Lord Electric Company; 1927 to date, concrete designer, Stone & Webster, Inc. Refers to *R. E. Baker, S. K. Cohen, J. A. Howe, J. C. Nowell, Jr.*

Shanbaum, Israel, Boston, Mass. (Age 22, b. Kovel, Poland.) Student at Northeastern University. During co-operative periods has been employed by

F. W. Bateman, Clinton. Refers to *W. J. Alcott, Jr., F. W. Bateman, G. B. Gee, J. W. Ingalls.*

Southworth, Edwin Warren, Jr., Winchester, Mass. (Age 24, b. Winchester, Mass.) Graduate of Massachusetts Institute of Technology, 1926. From October 18, 1926, to May 1, 1927, rodman for Metropolitan District Water Supply Commission; May 1, 1927, to date, instrumentman for same commission. Refers to *R. S. Holmgren, K. R. Kennison, T. H. Safford, W. H. Sears, F. E. Winsor.*

Stoddard, Woodworth Perkins, Brookline, Mass. (Age 24, b. Oneonta, N. Y.) Student at Northeastern University. During co-operative periods has been employed by E. W. Branch, Boston & Albany Railroad, Pearce & Beans, State Highway. Refers to *H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

Sweeney, Samuel W., East Milton, Mass. (Age 31, b. Boston, Mass.) Postgraduate, Mechanic Arts High School; attended Massachusetts Institute of Technology, 1914–15. Experience as draftsman, February, 1916, to February, 1918, October, 1919, to April, 1922, March, 1924, to November, 1924, with New England Structural Company; with Bethlehem Shipbuilding Corporation as rate setter, May, 1918, to August, 1919; draftsman with Boston Structural Steel Company, April, 1922, to January, 1924, November, 1924, to November, 1925; at present with Stone & Webster, Inc., as steel draftsman. Refers to *S. K. Cohen, J. A. Howe, R. G. Stafford, D. P. Tsagaris.*

Swirsky, Israel, Malden, Mass. (Age 27, b. Vilno, Russia.) Attended Mechanic Arts High School. Experience: in 1916 worked for Loring & Leland, architects; 1917–20, with Worthington Pump and Machinery Corporation, drafting room, as detailer and designer; 1920–22, with Boston Structural Steel Company; took a building course at Lowell Institute two years; 1920 to date, with West End Iron Works; at present taking charge of all estimating designing. Refers to *L. G. Brackett, B. S. Brown, Hyman Felderman, K. R. Garland, Mark Linenthal.*

Sylvester, Kenneth D., Boston, Mass. (Age 20, b. Westfield, Me.) Student at Northeastern University. During co-operative periods has been employed by Aspinwall & Lincoln. Refers to *W. J. Alcott, Jr., C. O. Baird, Jr., G. B. Gee, J. W. Ingalls, C. A. Wolfrum.*

Thurston, Victor A., Boston, Mass. (Age 19, b. Saco, Me.) Student at Northeastern University. During co-operative periods has been employed by Maine State Highway Commission; Massachusetts Highway; R. Loring Hayward. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., G. A. Haskins, J. W. Ingalls, A. M. Pillsbury.*

Thurston, Virgil A., Boston, Mass. (Age 19, b. Saco, Me.) Student at Northeastern University. During co-operative periods has been employed by Maine State Highway Commission, L. K. Perley, and R. Loring Hayward. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., G. A. Haskins, J. W. Ingalls.*

Tighe, John Gillman, Dorchester, Mass. (Age 21, b. Dorchester, Mass.) Student at Northeastern University. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, W. E. Nightingale.*

Ulm, Kenneth Surrell, West Somerville, Mass. (Age 21, b. Somerville, Mass.) Student at Northeastern University. During co-operative periods has been employed by Whitman & Howard, Barnes & Beal, and the town of Belmont. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls, W. E. Nightingale.*

Volpe, Sabestino, Atlantic, Mass. (Age 21, b. Italy.) Student at Northeastern University. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, C. A. Wolfrum.*

Voss, Walter Charles, Wellesley Farms, Mass. (Age 40, b. Chicago, Ill.) Graduate of University of Illinois in architectural engineering. Licensed architect in State of Illinois. From June, 1912, to September, 1914, structural detailer, designer and estimator; September, 1914, to February, 1925, head of department, architectural construction, Wentworth Institute, Boston; February, 1925, to date, district structural engineer, Portland Cement Association. Refers to *J. B.*

Babcock, M. N. Clair, F. M. Gunby, E. S. Larnes, L. E. Moore, L. C. Wason.

WHITE, CHARLES ALBERT, North Falmouth, Mass. (Age 20, b. Cambridge, Mass.) Is a student at Northeastern University. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, Jr., C. S. Ell, J. W. Ingalls.*

WHITE, FORREST SHERMAN, West Somerville, Mass. (Age 24, b. North Chelmsford, Mass.) Graduate of Massachusetts Institute of Technology in June, 1927, with B.S. in architectural engineering. During the summer of 1925 was employed by Mark Linenthal; during the summer of 1926 worked with M. E. Levy of Boston; since June, 1927, employed by Jackson & Moreland. Refers to *E. H. Cameron, W. D. Henderson, Mark Linenthal, C. M. Spofford.*

WILKINS, FRANCIS BLAKE, Beverly, Mass. (Age 33, b. Middleton, Mass.) Experience: one year, Boston & Albany Railroad; one year, T. A. Appleton, civil engineer, Salem; one year with Borden & Buffington, Fall River; ten years with Boston & Maine Railroad; one year with Metropolitan District Water Supply Commission. At present, draftsman for the last-named commission. Refers to *T. A. Appleton, R. S. Holmgren, K. R. Kennison, F. C. Shepherd, F. E. Winsor.*

WINEBAUM, THOMAS C., Allston, Mass. (Age 25, b. Russia.) Student at Northeastern University. During co-operative periods has been employed by Winebaum & Wexter, engineers and architects. Refers to *H. B. Alvord, C. O. Baird, Jr., G. A. Haskins, J. W. Ingalls, E. V. Lewis.*

WORCESTER, THOMAS, Waltham, Mass. (Age 31, b. Waltham, Mass.) Graduate of Harvard University in 1919 with A.B. degree. Attended Harvard Engineering School for one year after graduation. Experience: July, 1920, to May, 1921, worked for J. R. Worcester & Co., surveying, drafting and inspecting; May, 1921, to December, 1922, in city engineer's office, Waltham, as chief of party, drafting, inspecting and doing some designing; January, 1923, to December, same year, with C. D. Howe & Co., as draftsman and designer; January, 1924, to date, a partner in the firm of J. R. Worcester & Co. Refers to *G. H. Brazer, E. A. Norwood, E. E. Pettee, J. R. Worcester.*

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DEATH

CHARLES E. CHANDLER . Jan. 6, 1928

BOOK REVIEW

*"Regulation of Elevation and Discharge of the Great Lakes." Report by John R. Freeman of the Engineering Board of Review to The Sanitary District of Chicago. Dated December 30, 1925, and revised October 1, 1926.**

This very comprehensive report of over 560 pages comprises an investigation of the elevations and discharges of the Great Lakes, with suggested designs for gates, sluices, locks, etc., in the Niagara and St. Clair Rivers, to regulate the lakes at higher levels and to ensure more uniform discharge. At least eight causes are discussed as contributing to the variations in lake levels:

1. Rainfall and evaporation.
2. Seasonal variations.
3. Wind or barometric changes inducing waves, tides and seiches.
4. Effect of ice.
5. Earth tilt, dredging and scouring.
6. Diversions through canals.
7. The raising of Lake Superior through regulating works.
8. The raising of Lake Ontario by the Gut Dam and of St. Lawrence River by the temporary dam across South Sault.

In arriving at an analysis of these causes Mr. Freeman has collated a vast amount of information from all available sources.

Possible solutions offered for providing an increased depth for navigation are:

1. Raising the lake levels by means of regulating works.
2. Dredging shallow channels and harbors to permit increase in depth of draft of freight boats.
3. A combination of these two methods.

Mr. Freeman states that the total lowering caused by diversion of water through the Chicago Sanitary Canal, at any one of the Great Lakes (Superior excepted) has been only about 5 inches, while the lowering in recent years due to natural causes has amounted to about six times this, *i.e.*, climatic conditions (chiefly rainfall and evaporation) have caused a lowering of 2 to 3 feet within the past six to eight years. Mr. Freeman finds the present low condition of the lakes to be largely due to small rainfall, and cites facts which he believes indicate that soon the lakes will again begin to rise from natural causes. He further believes that notwithstanding the diversions by the Chicago Sanitary Canal and other canals at the present rate, in due course the lake levels would all return to within about 6 inches of their former heights, except for permanent lowering in some places caused by earth-tilt, dredging, scour and diminution of rainfall. The author has given especial attention to the matter of earth-tilt, and concludes that the evidence proves unmistakably the existence of a hinge line somewhere south of Chicago and Cleveland, inclined about 18½ degrees to the north of west, and a definite progressive uplift of the land to the north, in general, about one-half foot or more per 100 miles per century. This results in increasing the depths of the harbors at Chicago and Cleveland probably at the rate of more than a foot in one hundred years. He believes earth-tilt is largely responsible for the remarkable change in fall from Lake Huron to Lake Erie.

The regulating works proposed in Niagara River would cost about $8,000,000, and those in the St. Clair River about $25,000,000.

The suggested control works comprise a dam made up of arched concrete sluiceways with clear openings each about 72 feet wide, closed wholly or partially by gates of structural steel plates and girders, hinged at the base, so that they can lie flat on the bottom of the river or be raised to any desired height by strong chains on electrically driven winches. On Niagara River, where no boats pass, a concrete highway bridge is suggested, and in the St. Clair River four locks are provided.

In Appendix 4 the effect of change in

---

* Reviewed by Frank A. Marston (Metcalf & Eddy), assisted by Miss Ruth Canavan (Librarian, Metcalf & Eddy).

forest conditions on rainfall and run-off is considered.

The data forming the bases of Mr. Freeman's conclusions and recommendations are published in great detail and afford valuable records and discussions of rainfall, evaporation, temperature, lake levels and discharges, fog and ice conditions, earth-tilt, lake transportation, and the design of regulating works with an analysis of resulting backwater conditions. The subjects of evaporation and earth-tilt have been written up at great length for reference and to stimulate research.

Many diagrams and tables have been prepared, to illustrate the important points more clearly.

As a whole, the report is a valuable reference work and the author and his associates deserve much credit for their painstaking work.

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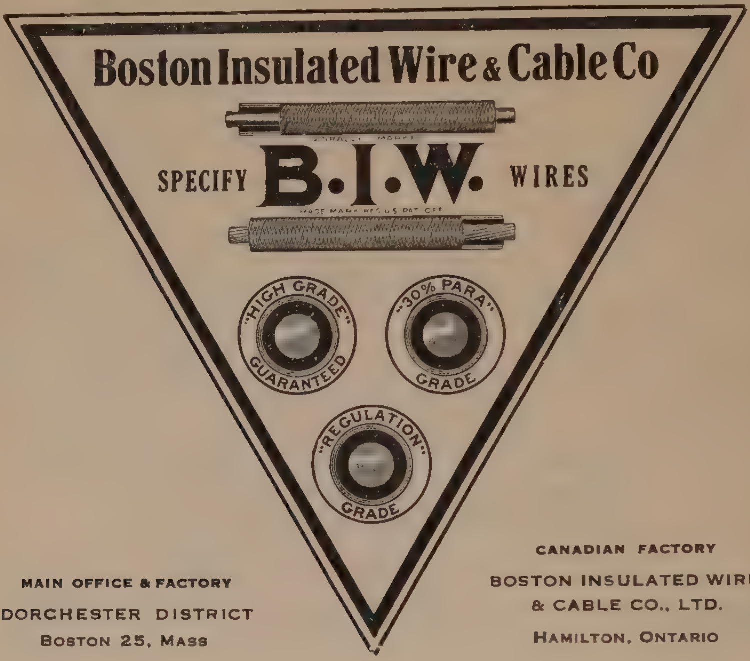

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